INSTRUCTIONS

198 4533K10-001
Formerly GEI-85950

TYPE 524
CURRENT – MODULATION CONTROLLER

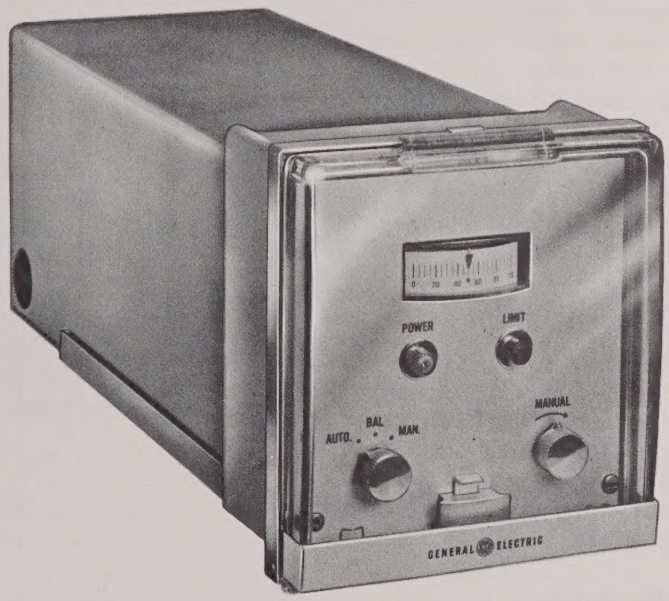


Fig. 1. Typical current-modulation controller

CONTENTS

	Page
INTRODUCTION	3
General	3
Specifications	3
RECEIVING, HANDLING, STORAGE, AND SHIPMENT	4
Receiving	4
Handling	4
Storage	4

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

GENERAL ELECTRIC

CONTENTS (Cont.)

Page

Shipment 4
DESCRIPTION 5
General 5
Case and Mounting Bracket Assembly 5
Controller Assembly 5
General 5
Front Control Panel 6
Side Control Panel 6
Control Amplifier 7
Manual-Control Circuit Board 7
Process Legend Clips 7
SPECIAL SERVICE TOOLS 8
INSTALLATION 8
General 8
Procedure 8
OPERATION 10
Operating Limits 10
Initial Servicing 10
Initial Operation 10
General 10
Controller Assembly Withdrawal 10
Recorder Adjustments 11
Controller Adjustments 11
Preliminary Control Settings 12
Operating Procedure 12
General 12
Manual Operation 12
Manual-to-Automatic Transfer 13
Automatic Operation 13
General 13
Initial Startup for Simple Process 13
Initial Startup for Complex Process 14
Automatic Process Startup 16
Automatic-to-Manual Transfer 16
PRINCIPLES OF OPERATION 17
General 17
Manual Operation 18
Manual-to-Automatic Transfer 18
Automatic Operation 18
General 18
Proportional Control 19
Rate Control 19
Reset Control 20
Control Amplifier 20
Limit Switch Circuits 23
Automatic-to-Manual Transfer 23
MAINTENANCE 23
Preventive Maintenance 23
Corrective Maintenance 23
Tests and Adjustments 23
Indicating Meter Adjustment 23
Control Amplifier Zero and Offset Adjustments 24

CONTENTS (Cont.)

Page

Repair and Replacement 25
General 25
Cover Plates 25
Control Amplifier Removal 25
Manual Control Supply Board Removal 25
Door Replacement 26
Semiconductor Replacement 26
Renewal Parts 26
TROUBLE SHOOTING 26
ILLUSTRATED PARTS BREAKDOWN 29
Introduction to Illustrated Parts Breakdown 29
General 29
Recommended Spare Parts List 29
Parts Breakdown 29
Numerical Parts List 29
Reference Designation List 30
How to Use the Illustrated Parts Breakdown 30
Recommended Spare Parts List 31
Parts Breakdown 32
Numerical Parts List 45
Reference Designation List 47

INTRODUCTION

GENERAL

These instructions cover the installation, operation, and maintenance of the General Electric Type 524 Current-Modulation Controller. This controller is installed with a strip-chart recorder which has a 5,000-ohm 100% control slidewire or a provision for adding one. Suitable recorders are General Electric Types HF, HR, HT, 520, and 521. The function of the controller is to provide a 10 to 50 ma control signal for a final-control element such as a magnetic amplifier and saturable reactor, an electro-pneumatic or electro-hydraulic valve operator, or a silicon controller-rectifier. The Type 524 Current-Modulation Controller provides both manual and automatic process control.

SPECIFICATIONS

Input Signal:	Error Signal from Indicators or Recorders such as General Electric Types HF, HR, HT, 520, and 521, which have 5,000-ohm 100% Slidewires
Slidewire Supply Voltage:	8.0 $\pm$ 0.5 VDC
Output Signal:	10 to 50 MA into 0 to 600 $\pm$ 10% Ohms
Control Methods:	Manual and Automatic
Automatic Control Modes:	3 (Proportional, Reset, and Rate)

Proportional Band:	2 to 500% (Gain of 50 to 0.2)
Reset Range:	0.04 to 10 Repeats per Minute (25 to 0.1 Minutes)
Rate Range:	0.1 to 25 Minutes
Approximate Rate Gain:	10
Power Requirement:	107 to 127 VAC, 50/60 $\pm$ 1 CPS, 20 WATTS
Ambient Temperature Range: (Continuous Operation)	+40°F to +120°F
Ambient Temperature Range: (Non-Continuous Operation)	+40°F to +140°F
Ambient Operational Humidity Range:	0 to 95% RH
Outline Dimensions:	Height - 6.84 Inches Width - 6.53 Inches Depth - 17.12 Inches
Approximate Net Weight:	20 Pounds
Approximate Shipping Weight:	35 Pounds

RECEIVING, HANDLING, STORAGE, AND SHIPMENT

RECEIVING

On receipt of the controller, examine it immediately for any damage that might have occurred in transit. Immediate examination is especially important if rough handling is evident. If damage is found, a damage claim should be filed immediately with the transportation company, and the nearest General Electric apparatus sales office should be notified promptly.

HANDLING

The controller is a rugged electronic unit weighing approximately 20 pounds. Observe normal precautions for electronic equipment during handling.

STORAGE

If the controller is to be stored prior to use, repack it in its original packing material and container, if possible. Store it in an area free from corrosive vapors, excessive vibration and shock, and extremes of temperature.

SHIPMENT

If the controller is to be reshipped, repack it in its original packing material and container, if possible. Use a method of shipment which will insure that normal precautions for electronic equipment are observed.

DESCRIPTION

GENERAL

The Type 524 Current-Modulation Controller consists of a case and mounting bracket assembly and the controller assembly. (See Fig. 1, Fig. 2, and Fig. 3.)

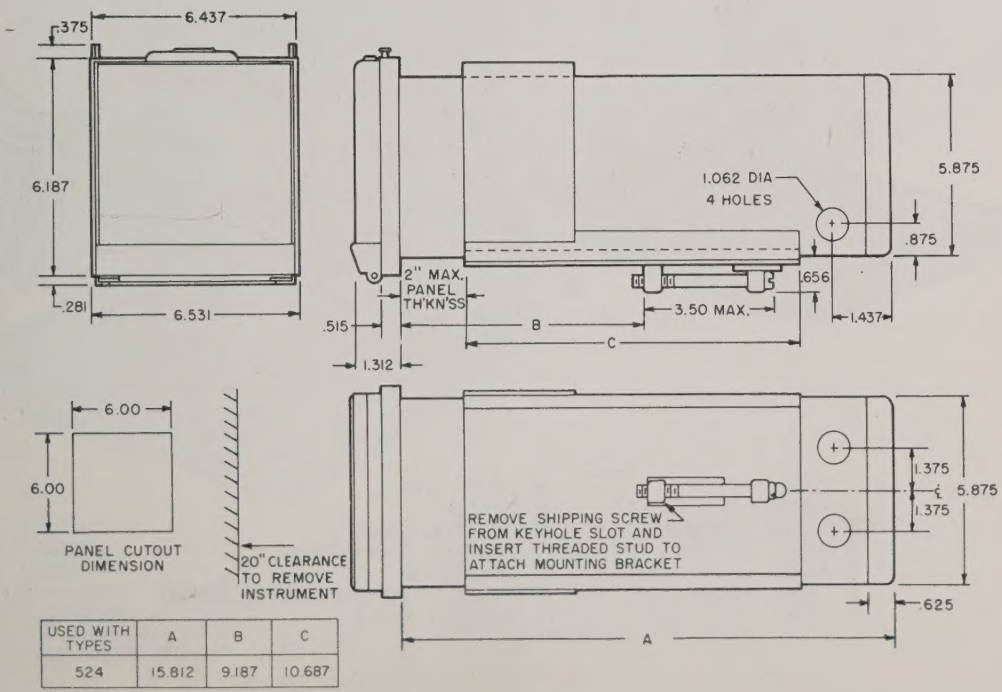
CASE AND MOUNTING BRACKET ASSEMBLY

The case and mounting bracket assembly encloses the controller assembly, and provides for panel-mounting of the controller. (See Fig. 1, Fig. 2, and Fig. 3.) A terminal board on the rear of the case provides for external electrical connections. This terminal board is protected by a cover plate. Cabling or conduit is routed to the terminal board through conduit holes in the rear of the case. A cable assembly (3) and plug (4) connect the case terminal board to the connector (12) at the rear of the controller assembly. (See Fig. 3.) The fuse (5) which protects the power circuit is located in this plug.

CONTROLLER ASSEMBLY (See Fig. 3 and Fig. 4.)

General (See Fig. 3.)

The controller assembly consists of the control unit (10) with operating controls and adjustments, the control amplifier (11), and the manual-control circuit board (13).



USED WITH TYPES	A	B	C
524	15.812	9.187	10.687

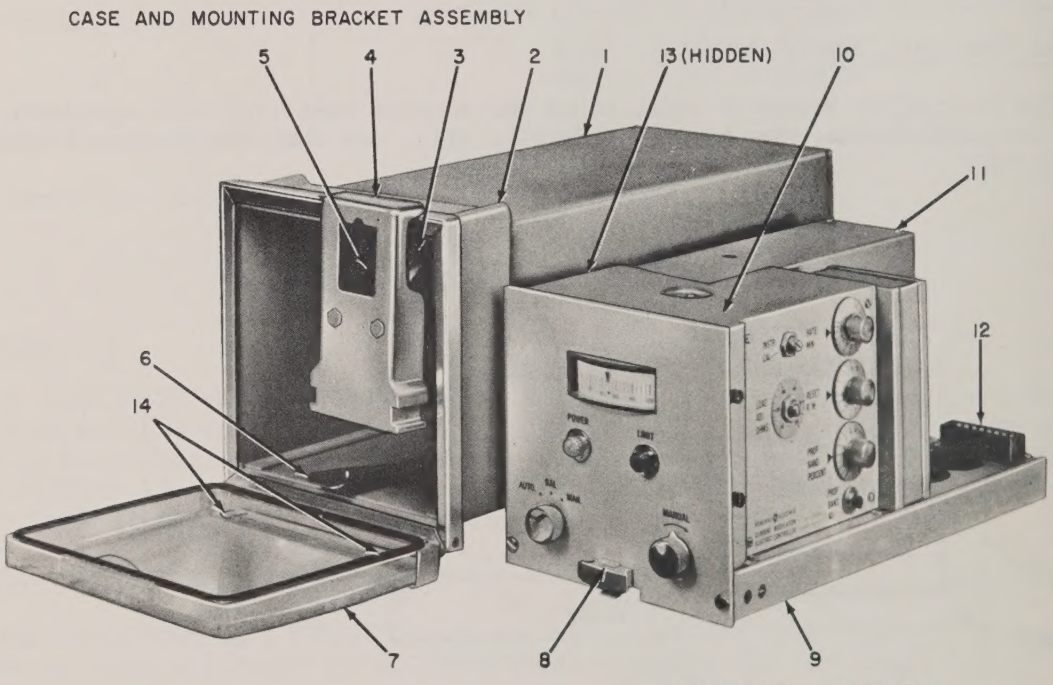
Fig. 2. Outline dimensions of typical current-modulation controller

Front Control Panel (See Fig. 4.)

The front control panel contains the most frequently used controls and indicators. They are the indicating meter (1), the POWER lamp (2), the LIMIT lamp (3), the AUTO./BAL./MAN. transfer switch (4), and the MANUAL control (5).

Side Control Panel (See Fig. 4.)

The side control panel contains the controls and adjustments normally used only when the controller is first put in operation. These controls and adjustments seldom require readjustment during operation of the controller with an established process. They are the LOAD ADJ OHMS adjustment (6), the INSTR CAL. adjustment (7), the PROP BAND ADJ pushbutton (8), the PROP BAND PERCENT control (9), the RESET R/M control (10), and the RATE MIN control (11). Also mounted on the side control panel are the output test jacks (12 and 13).



1. CASE
2. MOUNTING BRACKET
3. CABLE ASSEMBLY
4. PLUG
5. FUSE
6. LATCH LEVER
7. DOOR
8. LATCH BAR
9. CHASSIS
10. CONTROL UNIT
11. CONTROL AMPLIFIER
12. CONNECTOR
13. MANUAL-CONTROL CIRCUIT BOARD
14. PROCESS CLIPS

Fig. 3. Typical current-modulation controller with controller assembly removed from case

Control Amplifier (See Fig. 5.)

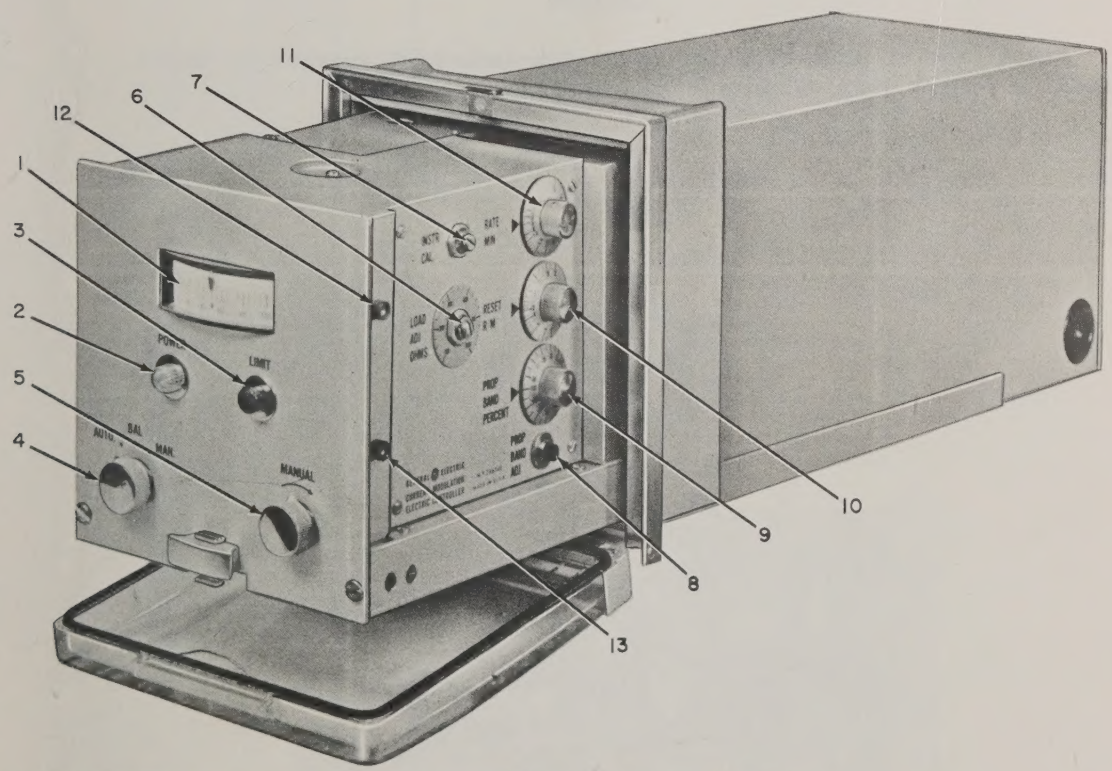
The plug-in control amplifier is of solid-state construction and includes a self-contained power supply. In addition, it contains a regulated power supply for operation of the control-slidewire circuit in the related recorder. When the controller is operated manually, the control amplifier may be removed for servicing without affecting the controller output.

Manual-Control Circuit Board

The plug-in manual-control circuit board contains a full-wave rectifier and a transistor regulator. It supplies the controller output current during manual operation, and also permits operation of the controller with the control amplifier removed.

Process Legend Clips (See Fig. 3.)

The two spring clips on the back of the door may be used to clip a process identification tag on the lower inside of the door.



1. INDICATING METER
2. POWER LAMP
3. LIMIT LAMP
4. AUTO./BAL./MAN. TRANSFER SWITCH
5. MANUAL CONTROL
6. LOAD ADJ OHMS ADJUSTMENT
7. INSTR CAL. ADJUSTMENT
8. PROP BAND ADJ PUSHBUTTON
9. PROP BAND PERCENT CONTROL
10. RESET R/M CONTROL
11. RATE MIN CONTROL
12. POSITIVE OUTPUT TEST JACK
13. NEGATIVE OUTPUT TEST JACK

Fig. 4. Typical current-modulation controller with controller assembly in half-extended position

SPECIAL SERVICE TOOLS

No special service tools are required to install, operate, or maintain the controller.

INSTALLATION

GENERAL

Install the controller in an area free from corrosive vapors, excessive vibration and shock, and extremes of temperature. (See Specifications.) In addition, mount the controller a reasonable distance from transformers or conductors carrying high currents. Outline and mounting dimensions and panel spacing requirements are shown in Fig. 2 and Fig. 6.

PROCEDURE

1. To facilitate panel mounting, remove controller assembly from case and mounting bracket assembly. (See Fig. 3.)

CAUTION

Place case on edge of bench or on one-inch-high support to avoid cracking hinges when opening door.

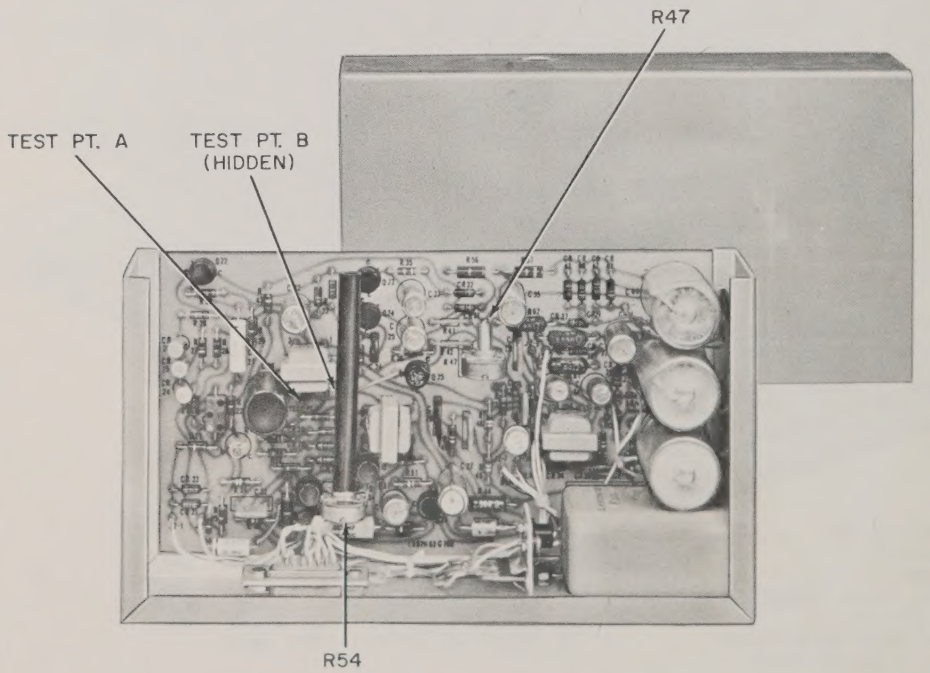


Fig. 5. Typical control amplifier with cover plate removed

a. Press latch release at top of case, and lower door clear of front panel.

b. Press centrally located latch bar on front panel, and partially withdraw controller assembly, releasing latch. Assembly will lock in half-extended position.

c. Press latch lever under controller assembly, and withdraw controller assembly farther, supporting it at base. Assembly will catch in fully-extended position.

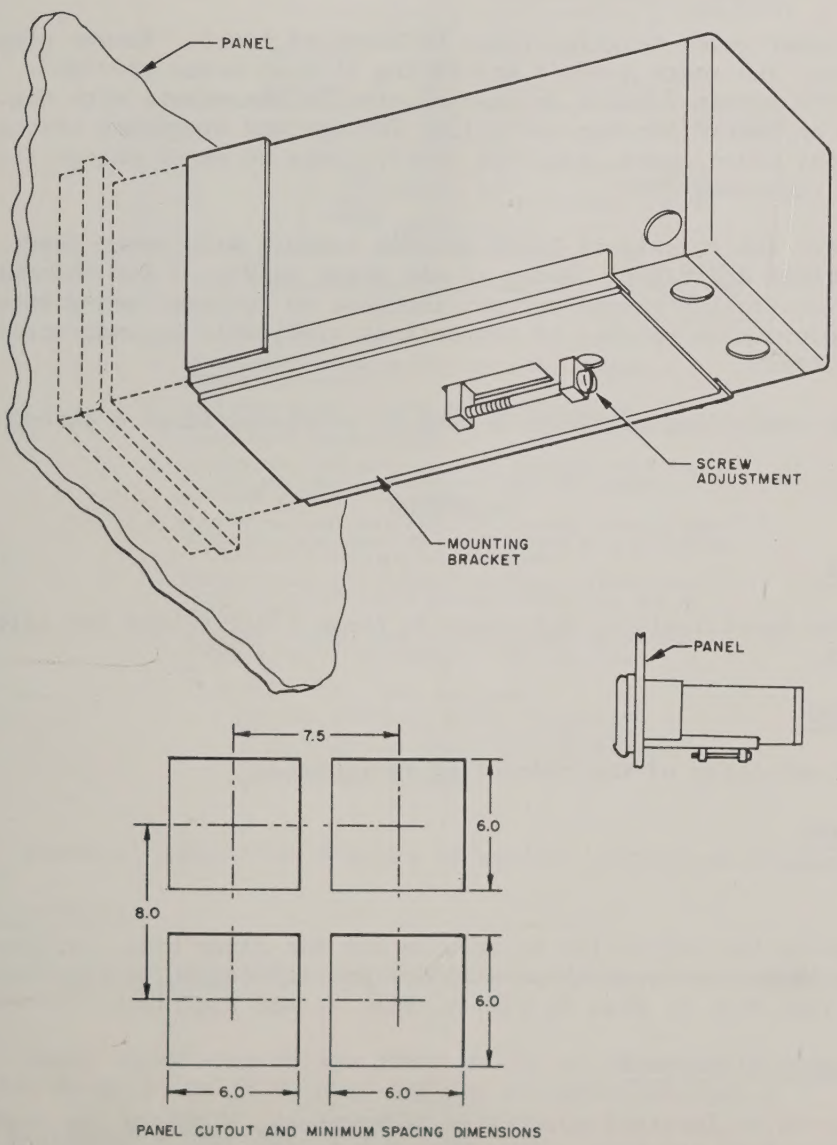


Fig. 6. Mounting dimensions of typical current-modulation controller

d. Disconnect plug from connector at rear of controller assembly.

e. Lift controller assembly up and out, and, supporting assembly at base, remove it from case. Set controller assembly aside in safe place.

2. Loosen adjustment screw from mounting bracket, detaching mounting stud by pushing it toward front of case. (See Fig. 6.)

3. Insert case into panel opening from front, and slide mounting bracket into position from rear. (See Fig. 6.)

4. Replace mounting stud, locking it by pressing it while holding mounting bracket in position. Clamp case firmly to panel by tightening adjustment screw. (See Fig. 6.)

5. Remove rear cover to gain access to terminal board. Remove plug buttons from rear of case, and route conduit or cabling through holes provided. Make external connections to terminal board on rear of case in accordance with Fig. 7. Refer to rating plate on controller for controller voltage and frequency ratings. When replacing terminal board cover, position locking lugs so as to engage lip of case when screws are tightened.

Note: Do not install signal leads in same conduit with power leads. Make sure all connections are tight. Refer to the notes in Fig. 7 for information on the relation of controller output current increase to recorder pen-pointer movement, and for information related to connections applicable to snap-action limit switches on recorder.

6. Replace controller assembly in case by reversing steps e through a of step 1.

OPERATION

OPERATING LIMITS

Refer to the Specifications paragraph of these instructions for allowable operating limits.

INITIAL SERVICING

No initial servicing of the controller is required.

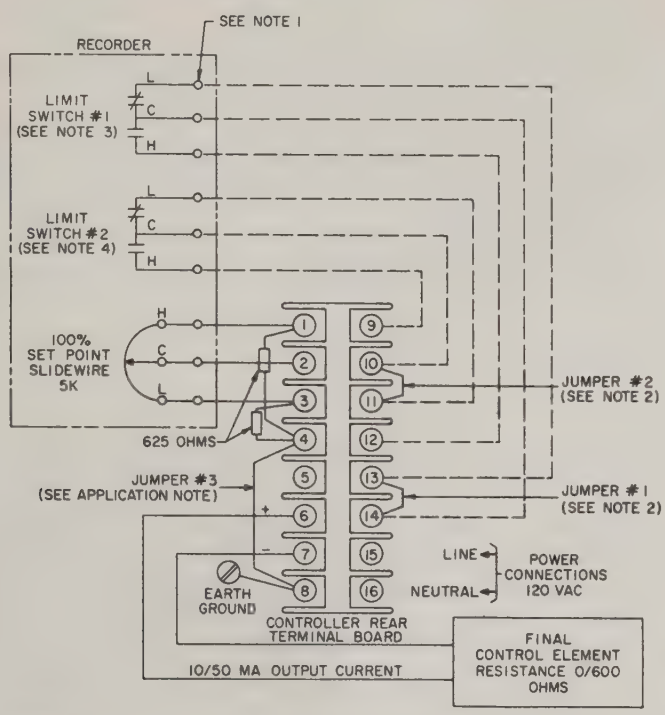
INITIAL OPERATION

General

Before placing the controller in service for the first time, perform the following tests and adjustments on the controller and its companion recorder in the order listed. (See Fig. 1, Fig. 3, Fig. 4, Fig. 7, and Fig. 15.)

Controller Assembly Withdrawal

To gain access to internal controller adjustments, withdraw the controller assembly partially from its case. (See Fig. 3.)



NOTES:

1. FOR RECORDER TERMINAL NUMBERS, SEE CONTROL DIAGRAM IN RECORDER INSTRUCTIONS.
2. LIMIT ("SNAP-ACTION") SWITCHES ARE NOT REQUIRED FOR CONTROLLER OPERATION. TO USE LIMIT FEATURE, REMOVE APPROPRIATE JUMPER FROM TERMINAL BOARD.
3. IF CONNECTED, LIMIT SWITCH NO. 1 WILL DECREASE OUTPUT CURRENT TO ZERO AND LIGHT LIMIT LAMP WHEN OPERATED. REMOVE JUMPER NO. 1 WHEN SWITCH IS CONNECTED.
4. IF CONNECTED, LIMIT SWITCH NO. 2 WILL INCREASE OUTPUT CURRENT TO MAXIMUM WHEN OPERATED. REMOVE JUMPER NO. 2 WHEN SWITCH IS CONNECTED. (LIMIT LAMP WILL NOT LIGHT.)
5. WIRED AS SHOWN, OUTPUT CURRENT INCREASES AND METER GOES TOWARD 100 WHEN RECORDER POINTER MOVES TO LEFT SIDE OF CONTROL POINT.
6. TO REVERSE CONTROL ACTION, INTERCHANGE CONNECTIONS FROM CONTROL SLIDEWIRE TO CONTROLLER TERMINALS 1 AND 3.

APPLICATION NOTE

FOR THOSE APPLICATIONS REQUIRING AN UNGROUNDED INPUT, REMOVE JUMPER NO. 3. VOLTAGE FROM INPUT TO GROUND MUST NOT EXCEED ± 30 VDC AND RESISTANCE FROM INPUT TO GROUND MUST NOT EXCEED 1 MEGOHM WHEN INPUT IS NOT GROUNDED.

Fig. 7. External connection diagram of typical current-modulation controller

Recorder Adjustments

1. With system power OFF, position recorder set-pointer at desired control point on recorder scale.

2. If used, check snap-action limit switch adjustments in recorder. (Refer to Fig. 7 for description of purpose and use of these switches.)

Controller Adjustments (See Fig. 4.)

1. With system power OFF, disconnect one of load leads (TB1-6 or TB1-7) from terminal board at rear of case.

2. Measure d-c resistance of controller load (final-control element) with ohmmeter. Denote this resistance value R_L.

3. Adjust LOAD ADJ OHMS adjustment, on side panel of control unit, for dial reading of R_L. Use slot in shaft as indicator.

4. Reconnect load lead disconnected in step 1.

Preliminary Control Settings (See Fig. 4.)

1. With system power OFF, make preliminary control settings in accordance with Table I.

TABLE I

PRELIMINARY CONTROL SETTINGS

Front Panel Controls		Side Panel Controls	
Control	Setting	Control	Setting
AUTO./BAL./MAN. Transfer Switch	MAN.	PROP BAND PERCENT	100%
MANUAL Control	Fully CCW (Zero Current Output)	RESET R/M	Minimum (Less than 0.04 Repeat Per Minute)
		RATE MIN	Minimum (Less than 0.1 Minute)

OPERATING PROCEDURE

General

An indicating meter, a POWER lamp, a LIMIT lamp, an AUTO./BAL./MAN. transfer switch, and a MANUAL control are mounted on the front panel of the controller. With the transfer switch in the MAN. or AUTO. position, the indicating meter reads controller output current in percent. (0% represents an output current of 10 ma, and 100% represents an output current of 50 ma.) With the transfer switch in the BAL. position, the indicating meter reads the difference between the control amplifier output current and the manual control power supply output current. This difference is zero when the meter pointer is aligned with the red dot in the center of the scale; a transfer from automatic to manual operation can then be made without incurring a change in the controller output current. The POWER lamp indicates when the controller is energized. When limit switch No. 1 in the companion recorder is used, the LIMIT lamp indicates when the No. 1 limit has been exceeded and controller output current reduced to 0 ma. The AUTO./BAL./MAN. transfer switch determines the control method (manual or automatic) and meter reading. The MANUAL control adjusts the output current from the manual control power supply.

Manual Operation

1. Energize process system, including recorder and controller.

2. Adjust process with MANUAL control, on front panel, until process stabilizes at desired value.

Manual-to-Automatic Transfer

1. Turn AUTO./BAL./MAN. transfer switch, on front panel, to AUTO. position.

Note: Controller can be transferred from manual to automatic operation without causing a "bump" in response. However, if recorder pen-pointer is not aligned with the set-point, transfer to automatic control will change current to output load in order to bring process to set point. If manual operation has stabilized at a desired point other than set point, reposition set point before transferring to automatic operation, so that process will remain at point stabilized under manual control.

Automatic Operation

General

Optimum process control is obtained by adjusting the PROP BAND PERCENT, RESET R/M, and RATE MIN controls on the side panel. The proper control settings depend on the response characteristics of the particular process. Usually, a control setting which produces good control of small variations in the process will also provide satisfactory "process startup" characteristics. In general, a process which requires a relatively fast change in control requirements will require a high setting of the RESET R/M control and a low setting of the RATE MIN control. Processes which exhibit large response changes for relatively small controller changes require a high PROP BAND PERCENT control setting.

There are many methods for determining process control settings. Many complex processes may be tuned for good control in minimum time using the "Ultimate Period" method, which is described in a later paragraph. However, some processes may not exhibit the oscillation required in using this method. Because processes such as an electric furnace with a sensing thermocouple may be practically represented by a single time constant, the gain of the controller may not be sufficient to bring the process into oscillation. Under these conditions, the PROP BAND PERCENT control will usually be finally set very narrow (between 5% and 20%). The RATE MIN control may usually be set near minimum (0.1 minute). The RESET R/M control should be set for as high a repeats per minute as possible, consistent with good startup, minimum overshoot, and process stability. Two initial startup methods for processes are described separately in the following paragraphs.

Initial Startup for Simple Process

1. Make preliminary control settings in accordance with Table I.

2. Stabilize process at desired operating point in manual operation.

3. Transfer process from manual to automatic control and let process stabilize. If process is not stable, increase setting of PROP BAND PERCENT control until stability is achieved.

4. Decrease setting of PROP BAND PERCENT control in small steps. Introduce small disturbance into system after each adjustment, to determine system response to new setting.

Note: PROP BAND ADJ pushbutton must always be depressed and held during adjustment of PROP BAND PERCENT control, and released after such adjustment to

observe process control. This prevents "bumps" in controller output current. Always allow sufficient time for process to stabilize after each adjustment.

5. Use Fig. 8 and Fig. 9 as guides in determining PROP BAND PERCENT control setting.

6. After determining approximate PROP BAND PERCENT control setting, increase setting of RESET R/M control in small increments. Introduce small disturbance into system after each incremental adjustment, to determine system response to new setting.

7. Use Fig. 10 and Fig. 11 as guides in determining RESET R/M control setting. It is desirable to have the maximum reset (in repeats per minute) consistent with process stability, minimum steady state offset, and good startup characteristics.

Note: As reset (in repeats per minute) is increased, process stability is decreased.

8. After determining approximate PROP BAND PERCENT and RESET R/M control settings, increase setting of RATE MIN control in small increments. Introduce small disturbance into system after each incremental adjustment, to determine system response to new setting.

9. Use Fig. 12 and Fig. 13 as guides in determining RATE MIN control setting.

Note: As RATE MIN control setting is increased, it may be necessary to decrease PROP BAND PERCENT control setting and/or RESET R/M control setting slightly. The product of the reset setting in repeats per minute and the rate setting in minutes should not exceed 1.0. For example, if reset setting is 2.0 repeats per minute, rate setting should not exceed 0.5 minute.

10. After initial control settings have been made, test system for control over expected range of set points. It may be necessary to readjust control settings slightly to maintain optimum performance at various set points.

Initial Startup for Complex Process

The "Ultimate Period" method of control adjustment usually results in excellent control performance for processes which may be represented by a combination of dead times and time constants. The following procedure outlines this method.

1. Make preliminary control settings in accordance with Table I.

2. Stabilize process at desired operating point in manual operation.

3. Transfer process from manual to automatic control and let process stabilize. If process is not stable, increase setting of PROP BAND PERCENT control until stability is achieved.

4. Press PROP BAND ADJ pushbutton, and simultaneously decrease PROP BAND PERCENT control setting in small steps.

Note: Pushbutton must always be depressed and held during adjustment of PROP BAND PERCENT control, and released after such adjustment to observe process control. This prevents transient "bumps" in controller output.

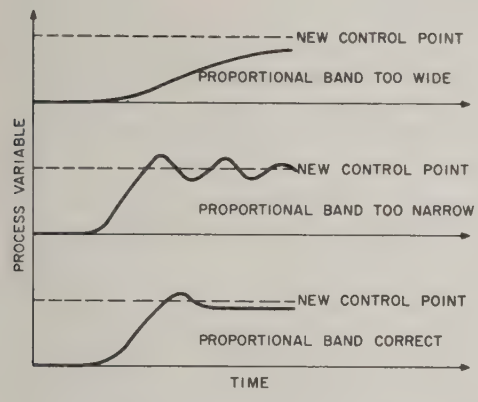


Fig. 8. Typical controller responses to change in set point for different proportional band settings

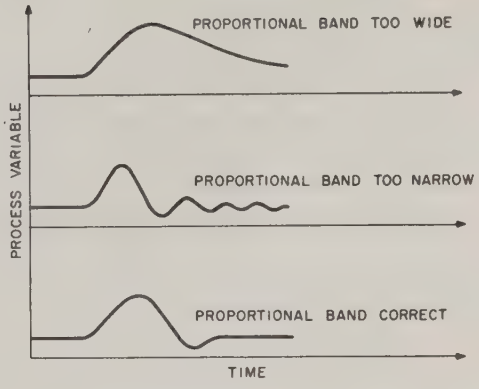


Fig. 9. Typical controller responses to change in demand for different proportional band settings

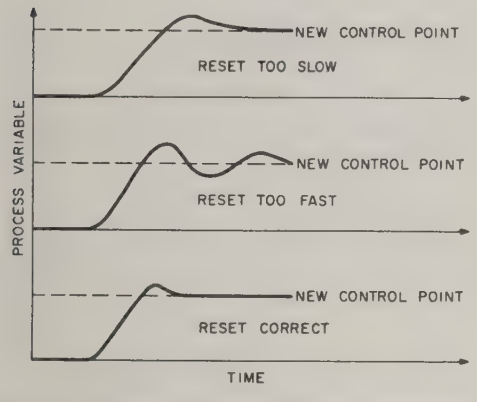


Fig. 10. Typical controller responses to change in set point for different reset settings

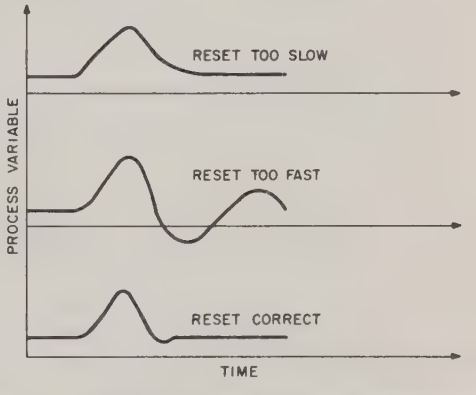


Fig. 11. Typical controller responses to change in demand for different reset settings

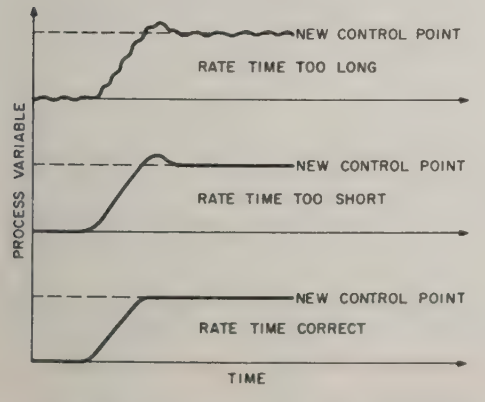


Fig. 12. Typical controller responses to change in set point for different rate settings

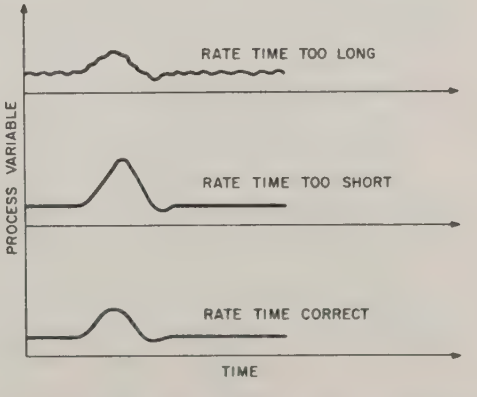


Fig. 13. Typical controller responses to change in demand for different rate settings

5. Continue to decrease setting of PROP BAND PERCENT control in small steps until recorder pen-pointer cycles at constant amplitude. Allow sufficient time after each adjustment for process to stabilize. Some processes may require a small disturbance (such as a small change in recorder set point) to start process cycling.

6. Measure time in minutes for one complete cycle, and note this time as t. Note setting of PROP BAND PERCENT control as PB.

7. Adjust PROP BAND PERCENT control for a setting of 2 to 3 times PB.

8. Adjust RESET R/M control for a setting of 2/t.

9. Adjust RATE MIN control for a setting of t/8.

10. Make final adjustments of controls listed in steps 7, 8, and 9 to obtain optimum response characteristics.

a. To prevent excessive cycling, increase setting of PROP BAND PERCENT control, and/or decrease setting of RESET R/M control.

b. To prevent excessive overshoot at startup, decrease setting of RESET R/M control.

c. To prevent excessive overshoot within proportional band, increase setting of RATE MIN control.

d. To correct undershoot, increase setting of RESET R/M control, and/or decrease setting of RATE MIN control.

11. Record all three final control settings.

Automatic Process Startup

Once the final control settings have been established, the controller will effect a process startup free of reset windup. If a startup having a minimum of overshoot is of primary importance, minor changes in control settings may be made without appreciably affecting process control. Excessive overshoot in process startup can be eliminated by a small decrease in the setting of the RESET R/M control. Undershoot can be corrected by a small increase in this setting.

Automatic-to-Manual Transfer

1. Turn AUTO./BAL./MAN. transfer switch, on front panel, to BAL. position.

2. Adjust MANUAL control, on front panel, until pointer of indicating meter rests at red dot on scale.

3. Turn AUTO./BAL./MAN. transfer switch, on front panel, to MAN. position. Output current is now controlled by MANUAL control.

PRINCIPLES OF OPERATION

GENERAL

The Type 524 Current-Modulation Controller is installed with a strip-chart recorder which has a 5,000-ohm 100% control slidewire or a provision for adding one. Suitable recorders are General Electric Types HF, HR, HT, 520, and 521. The function of the controller is to provide a 10 to 50 ma control signal for a final-control element such as a magnetic amplifier and saturable reactor, an electro-pneumatic or electro-hydraulic valve operator, or a silicon controller-rectifier. The Type 524 Current-Modulation Controller provides both manual and automatic process control. A simplified functional diagram of a typical controller is shown in Fig. 14. A complete schematic diagram of such a controller is shown in Fig. 15. The schematic diagram of a typical control amplifier is shown in Fig. 16.

An indicating meter (M101), a POWER lamp (DS1), a LIMIT lamp (DS2), an AUTO./BAL./MAN. transfer switch (S1), and a MANUAL control (R111), are mounted on the front panel of the controller. With S1 in the MAN. or AUTO. position, M101 reads controller output current in percent. (0% represents an output current of 10 ma,

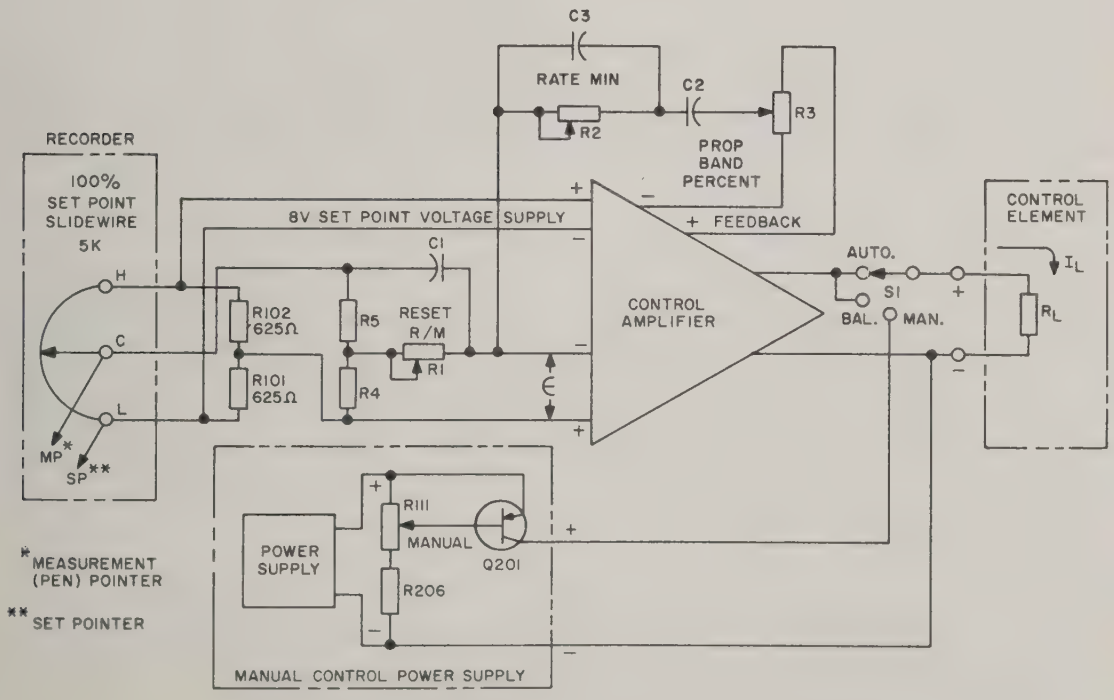


Fig. 14. Functional diagram of typical current-modulation controller

and 100% represents an output current of 50 ma.) With S1 in the BAL. position, M101 indicates the difference between the control amplifier output current and the manual control power supply output current. This difference is zero when the meter pointer is aligned with the red dot in the center of the scale. POWER lamp (DS1) indicates when the controller is energized. When limit switch No. 1 in the companion recorder is used, LIMIT lamp (DS2) indicates when the No. 1 limit has been exceeded and controller output current reduced to 0 ma. AUTO./BAL./MAN. transfer switch (S1) determines the control method (manual or automatic) and M101 reading. MANUAL control (R111) adjusts the output current from the manual control power supply.

In both manual and automatic control, the controller supplies a 10 to 50 ma output current to a 0 to 600 ± 10% ohms external load. Test jacks J4 and J5 are connected across a test resistor (R116) to facilitate calibration and testing. This circuit arrangement provides test signals of 10 to 50 millivolts for 10 to 50 milliamperes output current. The LOAD ADJ OHMS potentiometer (R112) is set for a dial reading equal to the resistance value of the external load, using the slot in the shaft as an indicator. This insures that the control amplifier load is approximately 600 ohms, regardless of the value (between 0 and 600 ohms) of the external controller load. The INSTR CAL potentiometer (R113) adjusts the bias current through the indicating meter (M101) when the AUTO./BAL./MAN. transfer switch (S1) is in the AUTO. or MAN. position. This current is obtained from the manual control power supply. It biases M101 so that it reads controller output current in percent, as described in the preceding paragraph.

MANUAL OPERATION

During manual operation, the output current to the external load is supplied by the zener-diode-regulated variable power supply. The MANUAL control potentiometer (R111) adjusts the base current of transistor Q201 to provide an adjustable current between 10 and 50 milliamperes.

MANUAL-TO-AUTOMATIC TRANSFER

During manual operation, the input to the control amplifier is connected differentially between resistors R204 and R205. This input is thus proportional to the difference between the manual control current and the control amplifier output current. The output current of the control amplifier is forced to equal the output current of the manual supply. Therefore, the controller may be transferred from manual to automatic operation without introducing a change in output current to the external load. No preliminary adjustments or balancing procedures are required.

AUTOMATIC OPERATION

General

During automatic operation, the 10 to 50 ma output current to the external load is supplied by the control amplifier. The value of this output current is determined by the error signal connected to the controller input terminals, and is such as to control the process at the recorder set point.

This error signal is obtained from the control slidewire in the companion recorder. The slidewire is a two-turn helix preventing the sliding contact from "running off the end" of the slidewire if the pen-pointer and the set-pointer are positioned at opposite scale extremes. The slidewire is connected as part of a

bridge circuit, which includes resistors R101 and R102 in the controller. The bridge supply voltage is provided by the control amplifier in the controller.

When the pen-pointer and the set-pointer are aligned on the recorder scale, the wiper of the control slidewire is at the electrical center of the slidewire, the bridge circuit is balanced, and the error signal is zero. If the pen-pointer and the set-pointer are not aligned, an error signal proportional in magnitude and responsive in polarity to the misalignment is produced by the bridge circuit.

The input, output, and feedback networks of the control amplifier are used to obtain a wide range of response characteristics in the controller. Controller output current is modified by control circuits to provide an output current with the desired control characteristics.

Proportional Control

Controller output current is proportional to the input error signal by a degree governed by the setting of the PROP BAND PERCENT control (R3), and controller gain assumes the following relationship:

$$\text{Controller Gain} = \frac{100\%}{\text{Proportional Band}} = \frac{\text{Percent Output Current Change}}{\text{Percent Input Signal Change}}$$

The $\pm$ 100% controller input range is $\pm$ 4V.

The degree of proportional control action depends on the value of the input error signal applied to capacitor C1, and the amount of negative feedback applied to capacitor C2. Increasing the negative feedback reduces controller gain. The proportional band is thus widened because the feedback is proportional to the controller output current.

The PROP BAND ADJ pushbutton (S2) is provided to permit adjustment of the PROP BAND PERCENT control (R3) with the controller in automatic operation, without producing a "bump" in controller output current because of a change in the charge on capacitor C2. When S2 is in its normal position, capacitor C103 shunts the controller feedback circuit and is charged by the feedback voltage. Pressing S2 opens the "ground" connection to C103, and reconnects C103 to the control amplifier input, which is now shunted by C5 and R10. Simultaneously, S2 removes the control amplifier input from the junction of R1 and C1 and "grounds" this junction. Also, resistor R7 is connected to "ground" by S2. Because the control amplifier input signal is relatively small in magnitude, the charge from capacitor C103 predominates and prevents feedback current from flowing, thus holding the controller output current constant.

With the PROP BAND ADJ pushbutton (S2) depressed, adjustment of the PROP BAND PERCENT control (R3) charges capacitor C2 to a new level. Releasing S2 restores the normal connections without affecting the controller output current.

Rate Control

With the RATE MIN control (R2) set at minimum, the controller output current changes are directly related to the rate of change of the input error signal. To provide an adjustable output current component proportional to this rate of change (in addition to the proportional output current component), the RATE MIN control

(R2) and capacitor C2 are inserted in the controller feedback circuit. The resultant "lagging" RC time constant in the feedback circuit produces a "leading" controller gain characteristic. Since the value of capacitor C2 is fixed, the time constant is determined by the R2 setting. A change in the value of the input error signal results in an output current change (from the controller) of a maximum approximately ten times greater than that produced by the action of the proportional control circuit alone. This increased change in the output current is present only during a changing input error signal. It does not occur when the error signal is of constant value.

Reset Control

Reset control action applies a corrective signal to the amplifier input for the purpose of reducing offset (a small discrepancy between the settings of the recorder pen-pointer and the recorder set-pointer) to a negligible value. The RESET R/M control (R1) and capacitor C1 form an RC time constant circuit with the time constant determined by the setting of potentiometer R1. A continuous offset error results in a steady corrective current through R1 to correct the controller output current by integrating the offset error. The rate of change (during correction) is determined by the degree of offset error, the setting of the RESET R/M control (R1), and the level of operation set by the PROP BAND PERCENT control (R3). Reset time is governed by the time constant of R1 and C1, and the ratio of resistance values of the signal-voltage-dividing resistors (R4 and R5).

Limiting diodes CR21 and CR22 in the control amplifier prevent reset windup during process startup. They limit the value of the error signal applied to the control amplifier, and produce a lead network at the amplifier input when a large error signal is present. During process startup, the control amplifier output can become saturated, if a large error signal has been present during shutdown. As recorder pen-pointer and recorder set-pointer approach a balanced position, the reset circuit (R1, C1, R4, and R5) reduces the error signal (before a balance is reached) to prevent startup overshoot. The limiter diode circuit causes the amplifier to come out of saturation approximately one reset time period before the process variable reaches the set point.

Control Amplifier

The control amplifier is a d-c operational amplifier using a 1,400 cps carrier frequency. The amplifier input impedance is approximately 2 megohms.

The d-c millivolt error signal is converted to an a-c signal by transistor chopper Q21. This a-c signal is amplified by an a-c amplifier consisting of transistors Q22, Q23, and Q24. The output is then demodulated by a ring demodulator (CR27 through CR30) and filtered. The filtered d-c signal is further amplified by a d-c amplifier consisting of Q25 and Q26. The Q26 output is used in two ways. First, it produces feedback voltage across the proportional band circuit for function generation of proportional, reset, and rate control. Secondly, it is converted to a-c by transistor chopper Q27, and coupled to output transistor Q30 by isolation transformer T23. Output transistor Q30 demodulates and provides power amplification, to produce a 10 to 50 ma output current into a 600-ohm load. Potentiometers R47 and R54, respectively, adjust the zero and offset of the control amplifier.

A unijunction oscillator (Q28) and an amplifier (Q29) provide the 1,400 cps chopper carrier frequency.

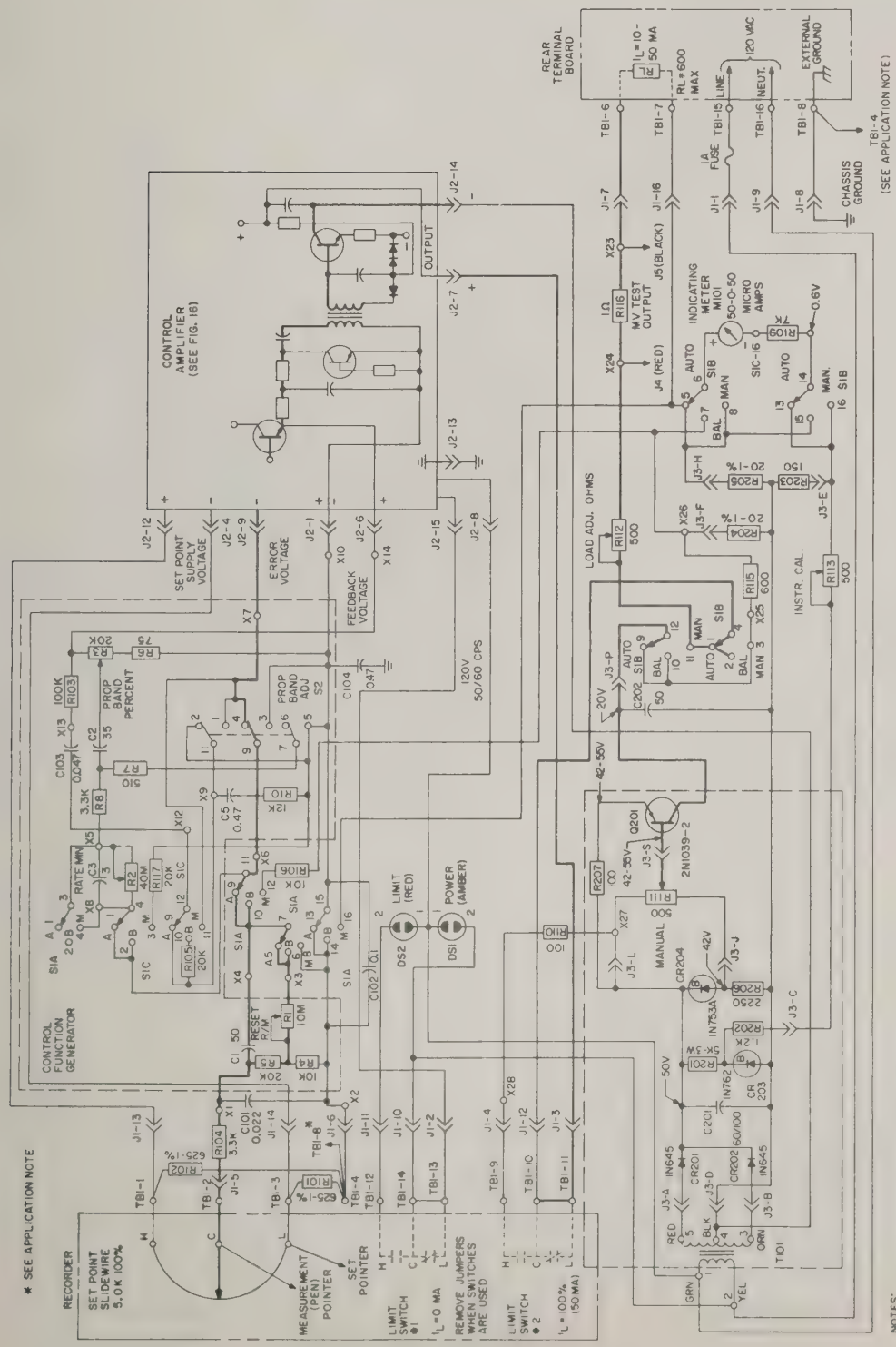

CONTROL AMPLIFIER (SEE FIG. 16)
OUTPUT
SET POINT SUPPLY VOLTAGE
ERROR VOLTAGE
FEEDBACK VOLTAGE
120V 50/60 CPS
CONTROL FUNCTION GENERATOR
RATE MIN
PROP BAND PERCENT
PROP BAND ADJ
RESET R/M
LIMIT (RED)
POWER (AMBER)
LOAD ADJ. OHMS
INSTR. CAL.
MANUAL
INDICATING METER M101 50-0-50 MICRO AMPS
MV TEST OUTPUT
REAR TERMINAL BOARD
EXTERNAL GROUND
CHASSIS GROUND
(SEE APPLICATION NOTE)
RECORDER
SET POINT SLIDEWIRE 5.0K 100%
MEASUREMENT (PEN) POINTER
SET POINTER
LIMIT SWITCH #1
LIMIT SWITCH #2
REMOVE JUMPERS WHEN SWITCHES ARE USED
* SEE APPLICATION NOTE
APPLICATION NOTE
FOR THOSE APPLICATIONS REQUIRING AN UNGROUNDED INPUT, REMOVE JUMPER BETWEEN TBI-4 AND TBI-8. VOLTAGE FROM INPUT TO GROUND MUST NOT EXCEED ± 30 VDC AND RESISTANCE FROM INPUT TO GROUND MUST NOT EXCEED 1 MEGOHM WHEN INPUT IS NOT GROUNDED.
NOTES:
1. ALL CAPACITOR VALUES ARE IN MICROFARADS.
2. ALL RESISTOR VALUES ARE IN OHMS, K = 1,000, M = 1,000,000.
3. 60/100V INDICATES 60 MFD AT 100 VOLTS, TYPICAL.
4. VOLTAGES ARE MEASURED WITH RESPECT TO POWER SUPPLY COMMON (J3-D) BY 20,000 OHMS/VOLT D-C VOLTMETER, WHILE CONTROLLER IS ON MANUAL AND METER AT CENTER SCALE.
5. "X" POINTS ARE LOCATED ON TERMINAL BOARDS UNDER CHASSIS.

Fig. 15. Schematic diagram of typical current-modulation controller

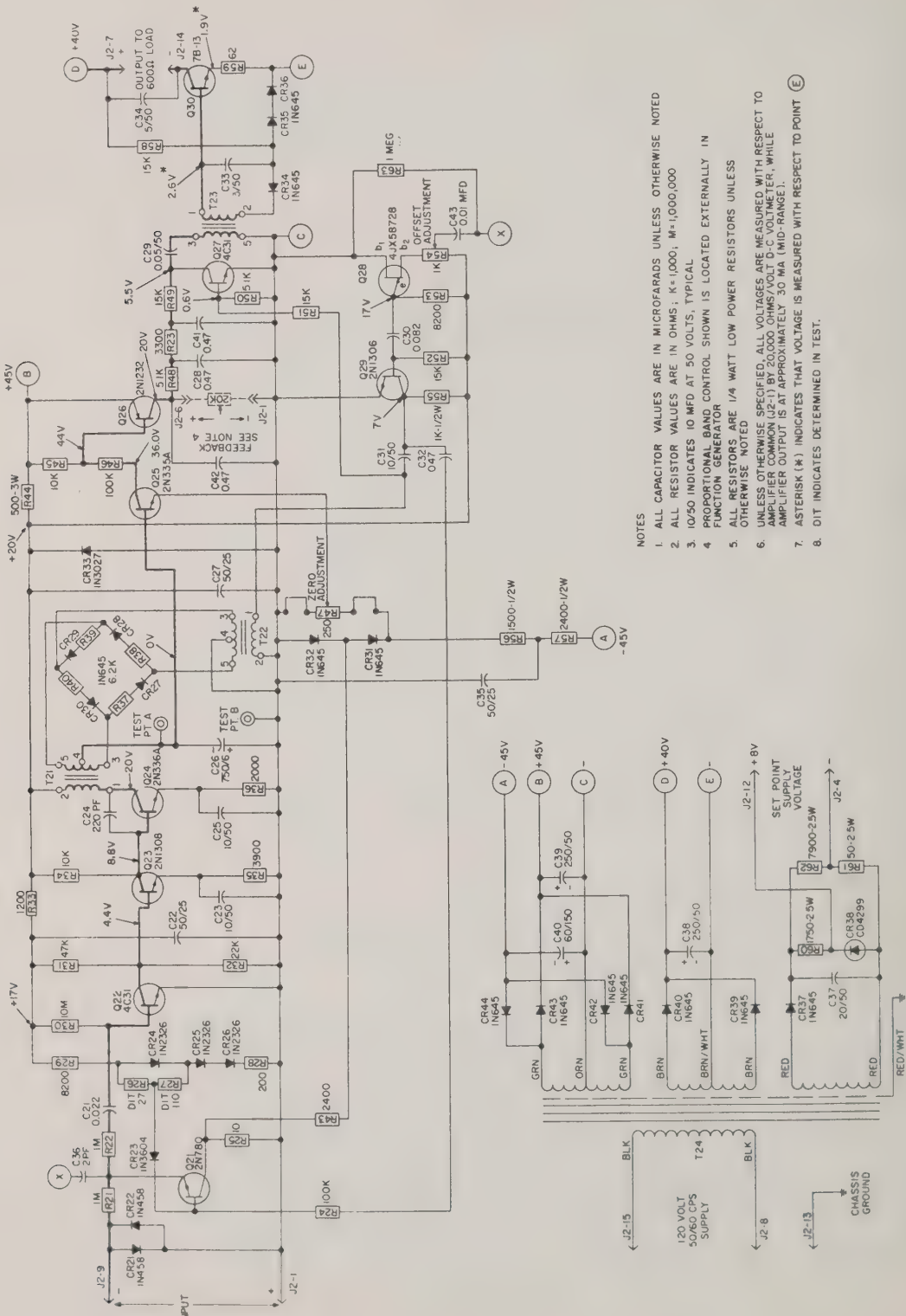

NOTES
1. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE NOTED
2. ALL RESISTOR VALUES ARE IN OHMS; K=1,000; M=1,000,000
3. 10/50 INDICATES 10 MFD AT 50 VOLTS, TYPICAL
4. PROPORTIONAL BAND CONTROL SHOWN IS LOCATED EXTERNALLY IN FUNCTION GENERATOR
5. ALL RESISTORS ARE 1/4 WATT LOW POWER RESISTORS UNLESS OTHERWISE NOTED
6. UNLESS OTHERWISE SPECIFIED, ALL VOLTAGES ARE MEASURED WITH RESPECT TO AMPLIFIER COMMON (J2-1) BY 20,000 OHMS/VOLT D-C VOLTMETER, WHILE AMPLIFIER OUTPUT IS AT APPROXIMATELY 30 MA (MID-RANGE).
7. ASTERISK (*) INDICATES THAT VOLTAGE IS MEASURED WITH RESPECT TO POINT (E)
8. DIT INDICATES DETERMINED IN TEST.
+45V
+20V
+17V
+40V
-45V
+8V
FEEDBACK SEE NOTE 4
ZERO ADJUSTMENT
OFFSET ADJUSTMENT
OUTPUT TO 600Ω LOAD
TEST PT A
TEST PT B
SET POINT SUPPLY VOLTAGE
120 VOLT 50/60 CPS SUPPLY
CHASSIS GROUND
INPUT

Fig. 16. Schematic diagram of typical control amplifier

The control amplifier contains its own d-c power supplies. A half-wave power supply with a zener reference diode (CR38) provides an 8-volt source for the set point slidewire in the recorder.

Limit Switch Circuits

When limit switch No. 1, on the companion recorder, is used, the jumper between TB1-13 and TB1-14 on the terminal board at the rear of the controller case is removed. If limit No. 1 is then exceeded, LIMIT lamp (DS2) lights, the control amplifier is de-energized, and the controller output current drops to 0 ma.

When limit switch No. 2, on the companion recorder, is used, the jumper between TB1-10 and TB1-11 on the terminal board at the rear of the controller case is removed. If limit No. 2 is then exceeded, the controller output current becomes approximately 50 ma, which is provided by the manual control power supply. In this case, LIMIT lamp (DS2) remains off.

AUTOMATIC-TO-MANUAL TRANSFER

A transfer of controller operation from automatic to manual can be made during operation without introducing a change in controller output current. Prior to the transfer, the AUTO./BAL./MAN. transfer switch (S1) is turned to the BAL. position. This connects the indicating meter (M101) differentially between resistors R204 and R205, but leaves the output of the control amplifier connected to the load. Meter M101 now reads the difference between the control amplifier output current through the external load and the manual control power supply current through dummy load resistor R115. The MANUAL control (R111) is used to adjust the manual control power supply current equal to the control amplifier output current by aligning the red dot on the meter scale with the meter pointer. (The controller remains in automatic operation during the balance.) A transfer from automatic to manual operation may then be made without incurring a change in the value of the controller output current.

MAINTENANCE

PREVENTIVE MAINTENANCE

No periodic maintenance procedures are required.

CORRECTIVE MAINTENANCE

Tests and Adjustments

Indicating Meter Adjustment

If indicating meter does not have meter pointer aligned with red dot on meter scale with controller de-energized, adjust it for a zero reading with screw adjustment on back of meter case (inside front panel).

If it is suspected that indicating meter is not reading controller output current correctly, perform the following steps in the order listed.

Note: AUTO./BAL./MAN. transfer switch must be in AUTO. or MAN. position for this adjustment.

1. Connect a potentiometer capable of measuring a 50 millivolt signal between test jacks on side panel. A 10-millivolt potentiometer reading should correspond with a 0% indicating meter reading, and a 50-millivolt potentiometer reading should correspond with a 100% indicating meter reading.

2. If correct indicating meter readings are not obtained, adjust INSTR CAL. potentiometer, on side panel, for correct readings. Required calibration accuracy is ± 3%.

Control Amplifier Zero and Offset Adjustments (See Fig. 5.)

Note: The control amplifier zero and offset adjustments (R47 and R54) are properly adjusted at the factory, and, under ordinary circumstances, should require no readjustment. However, if the amplifier zero or offset is suspected to be incorrect, perform the following steps in the order listed.

1. Prepare test set-up shown in Fig. 17.

2. Remove control amplifier cover.

3. Connect jumper between TEST PT. A and TEST PT. B on control amplifier printed circuit board.

4. Adjust zero potentiometer (R47), on control amplifier, for voltmeter reading of 18 ± 1 VDC.

5. Remove jumper between TEST PT. A and TEST PT. B on control amplifier printed circuit board.

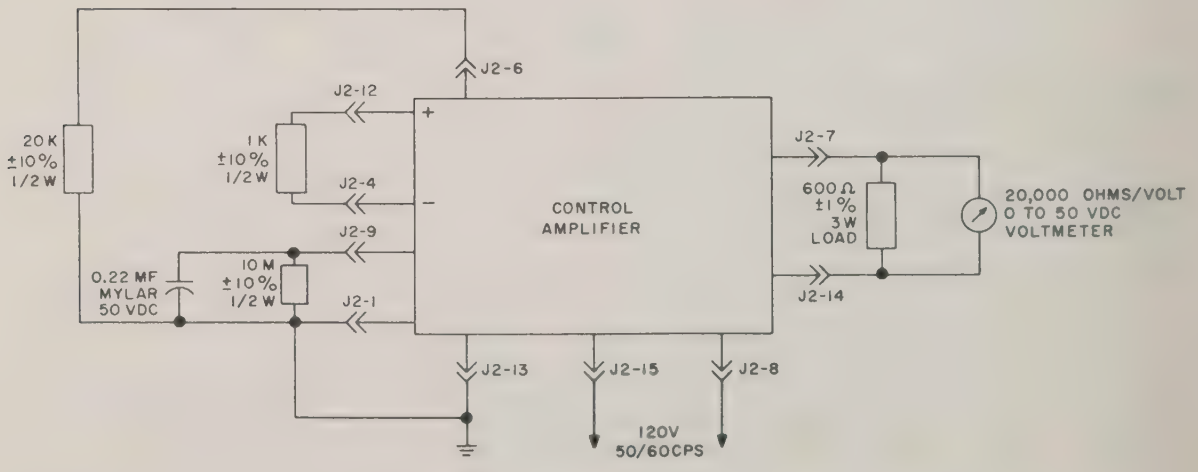


Fig. 17. Test set-up for typical control amplifier

6. Replace control amplifier cover and tighten screws which secure it.

7. Using screwdriver with insulated shaft, adjust offset potentiometer (R54), on control amplifier, for voltmeter reading of 18 ± 6 VDC. Adjust R54 through hole in top of amplifier cover.

Note: Since the control amplifier is not in a closed loop, a slow drift toward one or the other end of the voltmeter scale will be noted.

8. Disconnect test set-up shown in Fig. 17.

Repair and Replacement

General

If a component is to be returned to the factory for repair, obtain shipping instructions from the nearest General Electric apparatus sales office.

WARNING

USE CARE WHEN WORKING ON A CONTROLLER COMPONENT FROM WHICH THE COVER PLATE HAS BEEN REMOVED. DE-ENERGIZE CONTROLLER PRIOR TO REMOVAL OF ANY COMPONENT, AND RE-ENERGIZE CONTROLLER ONLY AFTER REPLACEMENT OF COMPONENT AND TIGHTENING OF CONNECTIONS.

Cover Plates

Major sections of the controller are protected by cover plates, which can be removed for inspection or adjustments. The control unit cover plate is secured by a captive screw in its center. The control amplifier cover plate is secured by two screws. The chassis bottom cover plate is secured by two screws at the rear of the chassis. This plate is removed by extracting the two screws and withdrawing the plate from the supporting grooves.

Control Amplifier Removal

Note: During manual operation of the controller, the control amplifier is not used, and can be removed for servicing. Use the following procedure to remove the control amplifier.

1. Withdraw controller assembly from case to point just beyond half-extended position.

2. Push control amplifier holdown, on bottom of controller assembly, up and toward rear of chassis, so that holdown lug clears slot in bottom of control amplifier.

3. Continue controller assembly withdrawal until control amplifier is clear of case, and unplug amplifier from chassis.

Note: To replace control amplifier, reverse steps 3 through 1.

Manual Control Supply Board Removal

Note: The manual control supply board must not be removed with the controller in operation.

1. Remove control amplifier as described in the preceding paragraph.

2. Loosen captive screw in center of control unit cover plate, and remove cover plate.

3. Remove screw near lower left corner of board.

4. Grasp top edge of board with fingers, and withdraw board from control unit with slight rocking motion.

Note: To replace manual control supply board, reverse steps 4 through 1.

Door Replacement

Use the following procedure to replace the door on the controller case.

1. Push in left and right pivot rods at bottom of door, maneuvering door so that rods remain pushed in. Use a bent paper clip or similar device to push in rods by inserting it through holes in door.

2. Remove door from case.

Note: Do not lose or misplace o-rings on pivot rods.

3. Slide new door over one pivot rod.

4. Push in other pivot rod with bent paper clip or similar device, and snap door over this rod, making sure that o-ring is in place.

Semiconductor Replacement

When replacing diodes or transistors, use extreme care to prevent heat from the soldering iron from damaging the component. Whenever possible, use long-nose pliers as a heat sink by holding the component lead with the pliers during the soldering operation.

Renewal Parts

Renewal parts, such as capacitors and transistors, should be obtained locally. If they cannot be obtained locally, they can be ordered from the nearest General Electric apparatus sales office. When ordering renewal parts, identify the part as completely as possible, giving the complete catalog number, if available, and any other identification, such as the reference designation on the wiring diagram. Also include on the order the quantity required and the complete model number of the controller (on the rating plate inside the case).

TROUBLE SHOOTING

It is recommended that only a qualified electronic technician be allowed to service or trouble shoot the controller. When trouble shooting the controller, refer to the schematic diagrams of Fig. 15 and Fig. 16. If trouble in a system has been isolated to the controller, use Table II as a trouble shooting guide.

CAUTION

Always de-energize controller before making ohmmeter checks.

TABLE II

TROUBLE SHOOTING

Symptom	Probable Cause and Remedy
I. Controller does not supply output current in either manual or automatic operation.	A. Blown power fuse. 1. Check power fuse (F1) on plug which mates with connector at rear of controller assembly. If fuse (F1) is blown, replace it after determining cause of blowing. B. Loss of a-c power. 1. Measure line voltage between TB1-15 and TB1-16 of terminal board in rear of controller case. If proper line voltage is not present, restore line voltage to correct operation. C. Open or shorted connections. 1. Inspect all pertinent circuitry for loose connections, short circuits, and frayed or broken leads. Correct any defect found.
II. Controller does not supply output current in manual operation.	A. Loss of manual control power supply voltage. 1. Check manual control supply board voltages at terminals of jack J3. All voltages are measured with respect to J3-D. B. Open or shorted connections. 1. Inspect all pertinent circuitry for loose connections, short circuits, and frayed or broken leads. Correct any defect found.
III. Controller does not supply output current in automatic operation.	A. Loss of set point supply voltage. 1. Measure d-c voltage between TB1-1 and TB1-3 of terminal board in rear of controller case. This voltage should read between 7 and 9 volts. If this voltage is not present, check for short or open circuit in wiring external to control amplifier. Correct short or open circuit if found. If no short or open circuit is found, set point supply of control amplifier is defective. Repair or replace defective control amplifier. B. Loss of input error signal. 1. Measure d-c voltage between TB1-2 and TB1-4 of terminal board in rear of controller case.

TABLE II TROUBLE SHOOTING (Cont.)

Symptom	Probable Cause and Remedy
III. (Cont.)	This voltage should vary from +4V to -4V as set point slidewire in companion recorder is turned from one extreme to the other. If no voltage is present, check pertinent circuit connections. If voltage does not respond smoothly, clean slidewire and check for good contact of wiper with slidewire mandrel. C. Open or shorted connections. 1. Inspect all pertinent circuitry for loose connections, short circuits, and frayed or broken leads. Correct any defect found. D. Defective controller circuitry. 1. Make voltage and resistance checks in pertinent controller circuitry. Repair or replace any component found defective. E. Defective control amplifier. 1. Repair or replace defective control amplifier.
IV. Controller output current is low in both manual and automatic operation.	A. Incorrect adjustment of LOAD ADJ OHMS potentiometer. 1. Perform steps 1 through 4 of Controller Adjustments subparagraph of Initial Operation paragraph of Operation section.
V. Sluggish controller response is observed in automatic operation.	A. Incorrect control setting. 1. Check settings of all controls. (Refer to Automatic Operation subparagraph of Operating Procedure paragraph of Operation section.) B. Low control amplifier gain. 1. Repair or replace defective control amplifier.

ILLUSTRATED PARTS BREAKDOWN

INTRODUCTION TO ILLUSTRATED PARTS BREAKDOWN

General

The illustrated parts breakdown is used as an aid in ordering and locating parts in the Type 524 Current-Modulation Controller, Cat. No. 2691K60G700, manufactured by the General Electric Company.

The parts breakdown is for the complete equipment, which is divided into nine assemblies. Each assembly listed is immediately followed by its components and/or parts properly indented to show relationship to the next higher assembly.

Recommended Spare Parts List

The recommended spare parts list is a list of spare parts recommended for maintenance and overhaul of one Type 524 Current-Modulation Controller. The G-E Cat. No. Column lists the General Electric catalog number. The Part Description Column lists a brief description of the part. The Quantity/Unit Column lists the quantity used in the equipment. The Quantity/Overhaul Column lists the quantity recommended per overhaul. The Remarks Column lists any additional pertinent information.

Parts Breakdown

The Figure and Index Number Column lists the figure and index number by which a particular part or assembly may be located on the applicable illustration.

The Part Number Column lists General Electric catalog numbers.

The Description Column lists the item name and/or a description of each part.

The Usage Code Column is left blank, because only one model is covered by the illustrated parts breakdown.

The Units Per Assembly Column lists the total quantity used at the particular location referred to by the figure and index number.

The following abbreviations and symbols are used in the Parts Breakdown:

REF - item listed for reference purpose.

NHA - next higher assembly.

---*--- - indicates end of attaching parts listing.

± - plus or minus (±).

Numerical Parts List

The Numerical Parts List consists of a numerical list of all part or catalog numbers appearing in the Parts Breakdown. These numbers are cross-referenced to the figure and index number and the total quantity used in one instrument.

The Numerical Parts List is compiled in accordance with the following system:

1. The sequence of part or catalog numbers with respect to the first position is as follows:

   a. Alphabetically, letters A through Z (alphabetical O's to be considered numerical zeros).

   b. Numerically, numbers 0 through 9.

2. The sequence of part or catalog numbers with respect to the second and succeeding positions is as follows:

   a. Space (blank column).

   b. Diagonal (slant).

   c. Point (period).

   d. Dash (-).

   e. Letters A through Z (alphabetical O's to be considered numerical zeros).

   f. Numbers 0 through 9.

3. The Figure and Index Number Column lists the figure and index number of each part.

4. The Quantity Per Instrument Column lists the total quantity of each item used in the equipment.

Reference Designation List

The Reference Designation List consists of a cross-reference between the reference designations which have been assigned to electronic and electrical parts, and the figure and index number and the part number of the particular part.

How to Use the Illustrated Parts Breakdown

The following instructions explain how to use the illustrated parts breakdown under two different circumstances.

1. When the part number is known:

   a. Turn to the Numerical Parts List and find the part number. Beside it is the figure and index number.

   b. Turn to the Parts Breakdown and locate the first figure number indicated. If the figure shows the part in a section other than the one desired, refer to the other figure numbers listed.

2. When the reference designation number is known:

   a. Turn to the Reference Designation List.

   b. Locate the reference designation number. Beside it is the figure and index number of the particular part.

c. Turn to the Parts Breakdown and locate the figure and index number indicated.

RECOMMENDED SPARE PARTS LIST

G-E CAT. NO.	PART DESCRIPTION	QUANTITY/ UNIT	QUANTITY/ OVERHAUL	REMARKS
3744K11P035	FUSE, CARTRIDGE, NON-INDICATING TYPE, 1A, 250V	1		
1096K41G700	AMPLIFIER ASSEMBLY	1	(See Remarks)	Recommend 1 spare for 10 or more controllers
1597K60G700	PRINTED CIRCUIT BOARD ASSEMBLY	1	(See Remarks)	Recommend 1 spare for 10 or more controllers

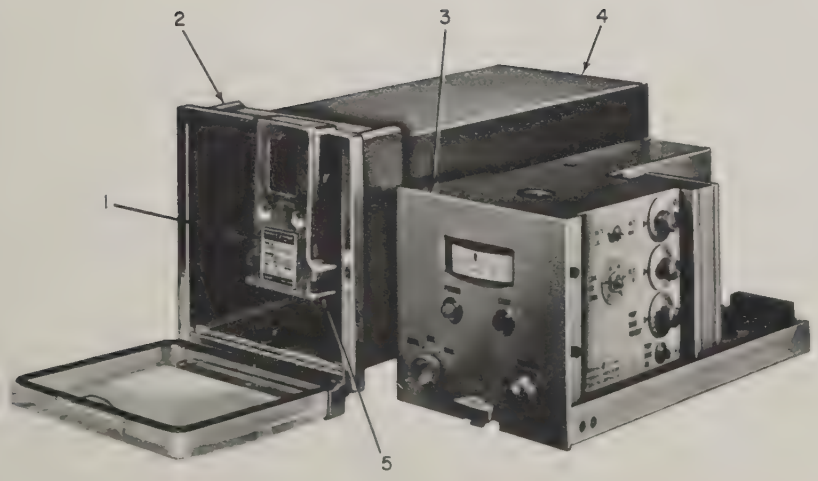


Fig. 18. Current-Modulation Controller Type 524 (sheet 1 of 2)

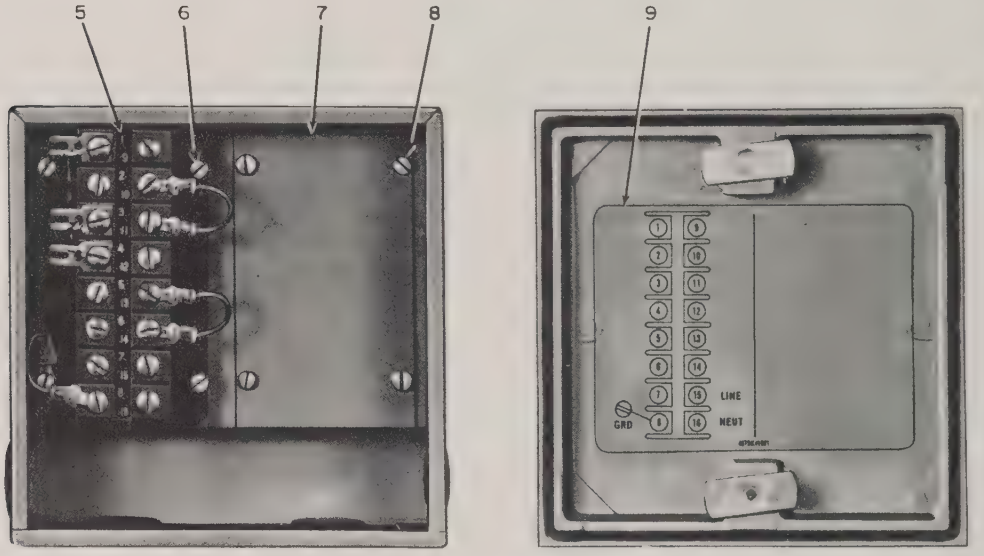


Fig. 18. Current-Modulation Controller Type 524 (sheet 2 of 2)

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
18 -	2691K60G700	CURRENT-MODULATION CONTROLLER TYPE 524		1
-1	5689K60P001	. PLATE, RATING, MADE FROM G-E CAT. . . . . NO. 6673K12P010		1
-2	8096K45G700	. SUPPORT		1
-3	2289K40G700	. CHASSIS ASSEMBLY, SEE FIGURE 19		1
-4	2177K60G700	. CASE ASSEMBLY, SEE FIGURE 26		1
-5	1952K60G700	. CABLE ASSEMBLY . . . . . ATTACHING PARTS		1
-6	*N75P13006E	. SCREW, MACHINE, PAN HD, NO. 6-32NC2A BY . . . . 3/8 IN. LG, BRASS, NI PL		4
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . 0.021 IN. THICK, PH BRZ, NI PL ---*--- PARTIAL BREAKDOWN FOLLOWS		4
	3744K11P035	. . FUSE, CARTRIDGE, NON-INDICATING TYPE, ... 1 AMP, 250 V		1
	4226K40P002	. . FUSEHOLDER		1
-7	5681K40P001	. PLATE COVER . . . . . ATTACHING PARTS		1
-8	*N75P13003E	. SCREW, MACHINE, PAN HD, NO. 6-32NC2A BY . . . . 3/16 IN. LG, BRASS, NI PL		4
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . 0.021 IN THICK, PH BRZ, NI PL ---*---		4
-9	4579K41P001	. INSULATOR		1
19 -	2289K40G700	CHASSIS ASSEMBLY, SEE 3 FIGURE 18 FOR NHA		REF
-1	4042K40G700	. GUARD ASSEMBLY . . . . . ATTACHING PARTS		1
-2	*N75P13004E	. SCREW, MACHINE, PAN HD, NO. 6-32NC2A BY . . . . 1/4 IN. LG, BRASS, NI PL		1
	*N414P13E	. WASHER, LOCK, INT TOOTH NO. 6, 0.295 OD BY . . 0.021 IN. THICK, BH PRZ, NI PL ---*---		1
	4579K43P002	. . INSULATOR		1
	4039K40P001	. . GUARD, DUST		1

*Minimum order quantity: 100 pieces

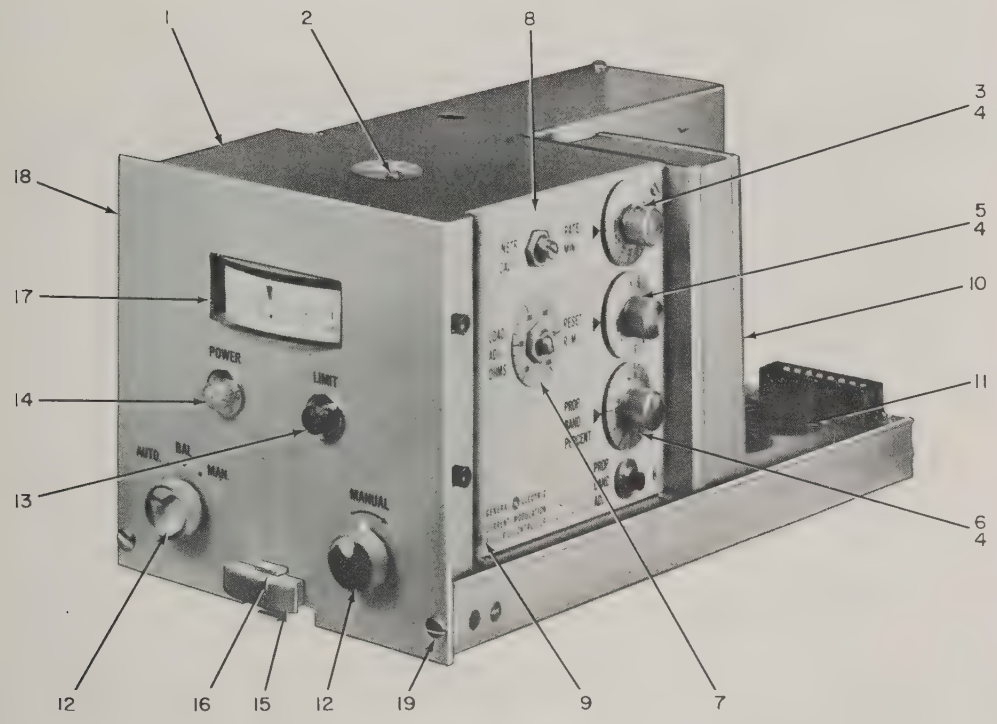


Fig. 19. Chassis assembly (sheet 1 of 2)

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
19 -3	3103K40G700	. DIAL ASSEMBLY		1
		ATTACHING PARTS		
	*N634P902	. SETSCREW, HEX SOCKET, CUP POINT, NO. 4-40NC3A . BY 1/8 IN. LG, SST, PASSIVATED		1
		---*---		
-4	2407K40P001	. CLUTCH		3
-5	3103K40G703	. DIAL ASSEMBLY		1
		ATTACHING PARTS		
	*N634P902	. SETSCREW, HEX SOCKET, CUP POINT, NO. 4-40NC3A . BY 1/8 IN. LG, SST, PASSIVATED		1
		---*---		
-6	3103K40G701	. DIAL ASSEMBLY		1
		ATTACHING PARTS		
	*N634P902	. SETSCREW, HEX SOCKET, CUP POINT, NO. 4-40NC3A . BY 1/8 IN. LG, SST, PASSIVATED		1
		---*---		
-7	5691K43P010	. PLATE, INFORMATION		1
-8	5691K43P005	. PLATE, INFORMATION		1
		ATTACHING PARTS		
-9	*N195P903	. SCREW, SELF-TAPPING, PAN HD, NO. 4-24 BY . . . 3/16 IN. LG, SST, PASSIVATED		4
		---*---		
-10	3919K40G700	. FUNCTION GENERATOR ASSEMBLY, SEE FIGURE 20 . .		1
		ATTACHING PARTS		
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . BY 0.021 IN. THICK, PH BRZ, NI PL		3

*Minimum order quantity: 100 pieces

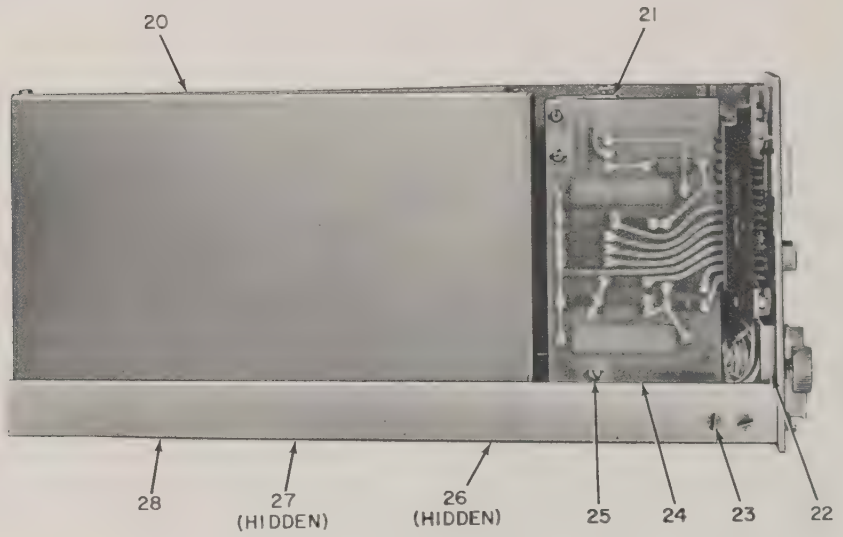


Fig. 19. Chassis assembly (sheet 2 of 2)

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
	*N250P13E	. NUT, PLAIN, HEXAGON, NO. 6-32NC2B, BRASS, NI PL		3
		---*---		
19 -11	5727K60P002	. BUTTON PLUG		2
-12	4798K62P001	. KNOB		2
		ATTACHING PARTS		
	*N634P902	. SETSCREW, HEX, SOCKET, CUP POINT NO. 4-40NC3A . BY 1/8 IN. LG, SST, PASSIVATED		1
		---*---		
-13	4223K62G700	. LAMPHOLDER ASSEMBLY		1
	4220K60P001	. . LAMPHOLDER, RED		1
	8311K27P002	. . TERMINAL		2
-14	4223K62G701	. LAMPHOLDER ASSEMBLY		1
	4220K60P002	. . LAMPHOLDER, AMBER		1
	8311K27P002	. . TERMINAL, LUG		2
-15	4113K40P001	. HANDLE		1
		ATTACHING PARTS		
	*N75P9005E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 5/16 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
		---*---		
-16	1338K42P001	. BAR, RELEASE		1
-17	185112CYCY1AA	. INDICATOR		1
		ATTACHING PARTS		
	*N40P9018E	. SCREW, MACHINE, FIL. HD, NO. 4-40NC2A BY . . . 1-1/8 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL		2
		---*---		
-18	5691K43P002	. PLATE, INFORMATION		1
		ATTACHING PARTS		
-19	*N195P1506	. SCREW, SELF-TAPPING, PAN HD, NO. 8-18 BY . . . 3/8 IN. LG, SST, PASSIVATED		2
		---*---		
-20	1096K41G700	. AMPLIFIER ASSEMBLY, SEE FIGURE 21		1

*Minimum order quantity: 100 pieces

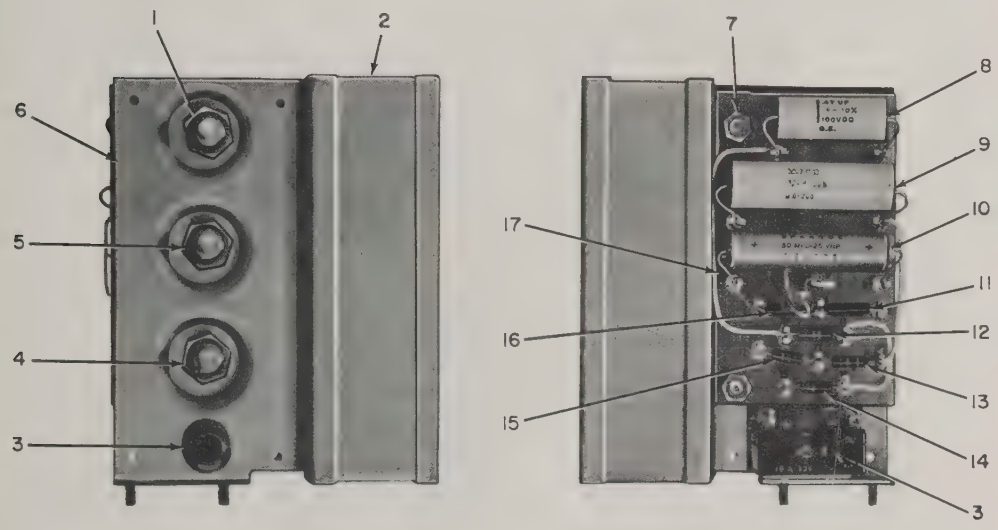


Fig. 20. Function generator assembly

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
19 -21	1714K64G700	. BRACKET ASSEMBLY . . . . . ATTACHING PARTS		1
	*N75P9020E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 1-1/4 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL ---*---		2
	1696K69P001	. . BRACKET		1
	*5438K60P004	. . NUT, CLINCH, NO. 6-32		1
-22	5558K60G700	. PANEL ASSEMBLY, SEE FIGURE 23 . . . . . ATTACHING PARTS		1
-23	*N47P13009E	. SCREW, MACHINE, FLAT HD, NO. 6-32NC2A BY . . . 9/16 IN. LG, BRASS, NI PL		4
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . 0.021 IN. THICK, PH BRZ, NI PL		4
	*N250P13E	. NUT, PLAIN, HEXAGON, NO. 6-32NC2B, BRASS, NI PL ---*---		4
-24	1597K60G700	. PRINTED CIRCUIT BOARD, SEE FIGURE 24 . . . . . ATTACHING PARTS		1
-25	*N75P9003E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 3/16 IN. LG, BRASS, NI PL ---*---		1
-26	5689K60P002	. PLATE, RATING, MADE FROM G-E CAT. NO. 6673K12P010		1
-27	5681K41P001	. PLATE		1
-28	5719K60G700	. CHASSIS PLATE ASSEMBLY, SEE FIGURE 25		1
20 -	3919K40G700	FUNCTION GENERATOR ASSEMBLY, ... SEE 10 FIGURE 19 FOR NHA		REF
-1	5839K40P004	. RESISTOR, VARIABLE, COMPOSITION, 40 MEG ± 30%, 1/2 W		1
-2	2101K41P001	. CAPACITOR, FIXED, ELECTROLYTIC, 35 UF ± 10%, . 50 WVDC ATTACHING PARTS		1
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . 0.021 IN. THICK, PH BRZ, NI PL		2
	*N207P13E	. NUT, PLAIN, HEXAGON, NO. 6-32NC2B, BRASS, NI PL ---*---		2

*Minimum order quantity: 100 pieces

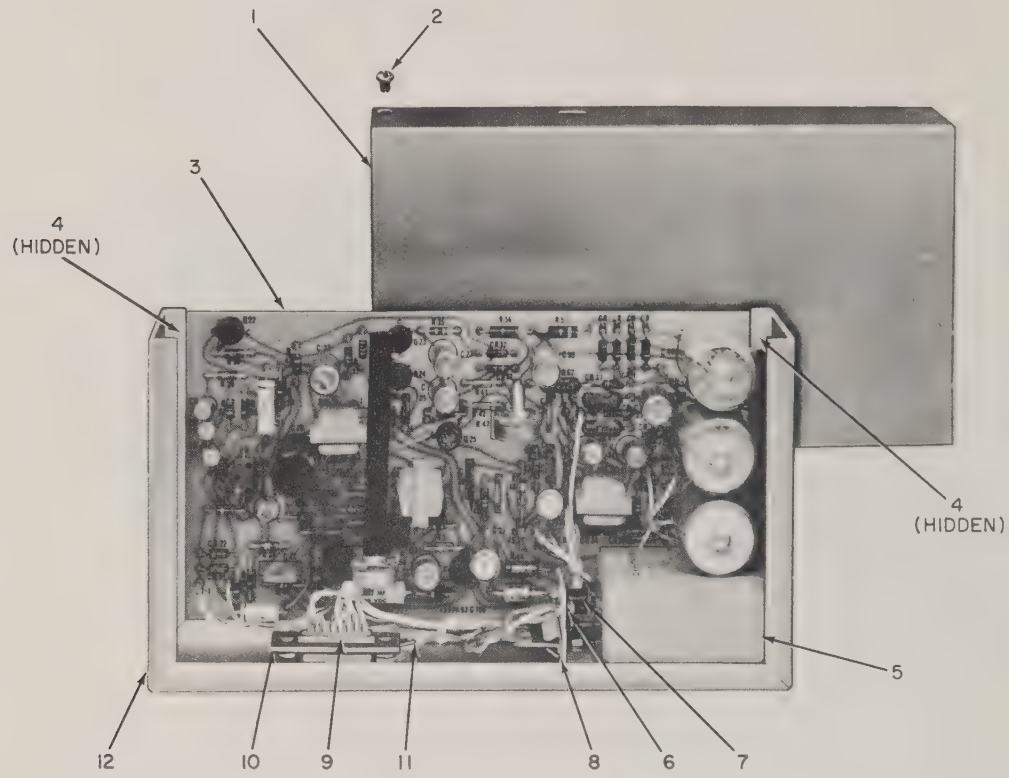


Fig. 21. Amplifier assembly

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
20 -3	8155K60P001	. SWITCH, PUSH, 3 PDT		1
-4	5839K40P006	. RESISTOR, VARIABLE, COMPOSITION, 20 K ◻ 10%, . 1/2 W		1
-5	5839K40P001	. RESISTOR, VARIABLE, COMPOSITION, 10 MEG ◻ 20%, 1/2 W		1
-6	1714K65G700	. BRACKET ASSEMBLY		1
	1695K42P001	. . BRACKET		1
	8072K60P001	. . STUD, CLINCH		2
	1596K62G700	. TERMINAL BOARD ASSEMBLY . . . . . ATTACHING PARTS		1
-7	*N43P13008E	. SCREW, MACHINE, HEXAGON HD, NO. 6-32NC2A BY . . 1/2 IN. LG., BRASS NI PL		1
	5809K66P001	. POST		2
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . 0.021 IN. THICK, PH BRZ, NI PL		2
	*N207P13E	. NUT, PLAIN, HEXAGON, NO. 6-32NC2B, BRASS, NI PL ---*---		2
-8	2108K13P067	. . CAPACITOR, FIXED, PLASTIC DIELECTRIC, ... 0.47 UF ◻ 10%, 100 WVDC		1
-9	2101K40P002	. . CAPACITOR, FIXED, METALIZED MYLAR, 3 UF, . . 300 WVDC		1
-10	2107K60P001	. . CAPACITOR, FIXED, ELECTROLYTIC, 50 UF, . . . 25 WVDC		1
-11	6143K12P109	. . RESISTOR, FIXED, COMPOSITION, 10 K ◻ 5%, . . 1/2 W, MILITARY TYPE, RC20GF103J		1
-12	6143K12P112	. . RESISTOR, FIXED, COMPOSITION, 12 K ◻ 5%, . . 1/2 W		1
-13	6143K12P091	. . RESISTOR, FIXED, COMPOSITION, 3.3 K ◻ 5%, . . 1/2 W		1

*Minimum order quantity: 100 pieces

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
20 -14	6143K12P033	. . RESISTOR, FIXED, COMPOSITION, 75 OHM ¤ 5%, . 1/2 W		1
-15	6143K12P063	. . RESISTOR, FIXED, COMPOSITION, 510 OHM ¤ 5%, . 1/2 W		1
-16	6143K12P120	. . RESISTOR, FIXED, COMPOSITION, 20 K ¤ 5%, . . 1/2 W		1
-17	1594K66G700	. . TERMINAL BOARD		1
21 -	1096K41G700	AMPLIFIER ASSEMBLY, SEE 20 FIGURE 19 FOR NHA . .		REF
-1	2827K46G700	. COVER ASSEMBLY . . . . . ATTACHING PARTS		1
-2	*N75P13003E	. SCREW, MACHINE, PAN HD, NO. 6-32NC2A BY . . . . 3/16 IN. LG, BRASS, NI PL ---*---		2
	2817K44P001	. . COVER		1
	4579K43P001	. . INSULATOR		1
-3	1597K63G700	. PRINTED CIRCUIT BOARD ASSEMBLY, SEE FIGURE 22 . ATTACHING PARTS		1
-4	*N632P13003E	. SETSCREW, NO. 6-32 BY 3/16 IN. LG. . . . . ---*---		2
-5	8600K61P001	. TRANSFORMER, MADE FROM G-E CAT. NO. . . . . 8600K40P001 ATTACHING PARTS		1
	*N47P13005E	. SCREW, MACHINE, FLAT HD, NO. 6-32NC2A BY . . . 5/16 IN. LG, BRASS, NI PL ---*---		2
-6	4594K60P001	. INSULATOR . . . . . ATTACHING PARTS		1
	*N75P7004E	. SCREW, MACHINE, PAN HD, NO. 3-48NC2A BY . . . . 1/4 IN. LG, BRASS, NI PL		2
	*8900K70P007	. WASHER, FLAT		2
	*N414P9E	. WASHER, LOCK, INT TOOTH, NO. 3, 0.232 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P7E	. NUT, PLAIN, HEXAGON, NO. 3-48NC2B, BRASS, NI PL ---*---		2
-7	6856K90P011	. TRANSISTOR		
-8	1714K63G700	. BRACKET ASSEMBLY . . . . . ATTACHING PARTS		1
	*N47P9005E	. SCREW, MACHINE, FLAT HD, NO. 4-40NC2A BY . . . 5/16 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL ---*---		2
	*N330P1205E	. . EYELET, 1/8 DIA BY 5/32 IN. LG, BRASS, NI PL		2
	8065K60P002	. . STRIP TERMINAL		1
	1696K68P001	. . BRACKET		1
-9	5730K90P003	. CONNECTOR, PLUG, ELECTRICAL . . . . . ATTACHING PARTS		1
	*N75P9004E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 1/4 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B . . . . . ---*---		2
-10	1696K70P001	. BRACKET . . . . . ATTACHING PARTS		1
	*N47P9005E	. SCREW, MACHINE, FLAT HD, NO. 4-40NC2A BY . . . 5/16 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL ---*---		2
-11	8311K17P003	. TERMINAL LOCKING		1
-12	2166K40P001	. CASE		1
22 -	1597K63G700	PRINTED CIRCUIT BOARD ASSEMBLY, ... SEE 3 FIGURE 21 FOR NHA		REF
-1	6854K90P023	. TRANSISTOR		1
-2	5535K40P001	. PAD, HEAT SINK		8
-3	6143K25P033	. RESISTOR, FIXED, COMPOSITION, 2.4 K ¤ 5%, 1/4 W		1
-4	6143K25P031	. RESISTOR, FIXED, COMPOSITION, 1.2 K ¤ 5%, 1/4 W		1
-5	2098K60P003	. CAPACITOR, FIXED, ELECTROLYTIC, 50 UF, 25 WVDC		3
-6	6143K25P046	. RESISTOR, FIXED, COMPOSITION, 10 K ¤ 5%, 1/4 W		2
-7	6143K25P030	. RESISTOR, FIXED, COMPOSITION, 22 K ¤ 5%, 1/4 W		1
-8	2092K90P026	. CAPACITOR, CERAMIC, 220 UUF ¤ 10%, 1000 WVDC .		1
-9	6143K25P029	. RESISTOR, FIXED, COMPOSITION, 47 K ¤ 5%, 1/4 W		1
-10	6854K90P010	. TRANSISTOR		1
-11	4068K60P001	. GUIDE		1
-12	6845K90P019	. TRANSISTOR		1

*Minimum order quantity: 100 pieces

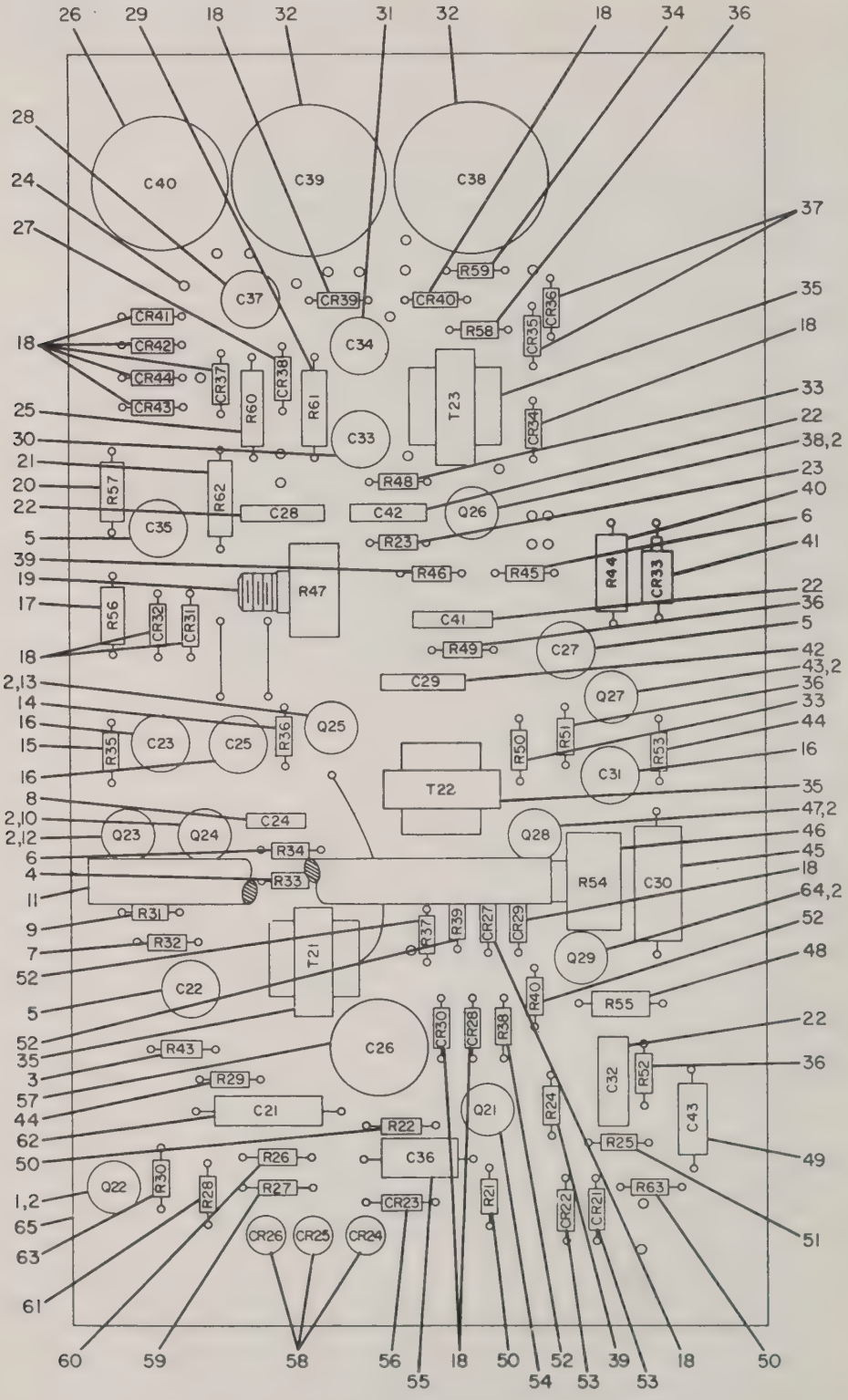


Fig. 22. Printed circuit board assembly

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
22 -13	6854K90P009	. TRANSISTOR		1
-14	6143K25P032	. RESISTOR, FIXED, COMPOSITION, 2 K ¤ 5%, 1/4 W .		1
-15	6143K25P045	. RESISTOR, FIXED, COMPOSITION, 3.9 K ¤ 5%, 1/4 W		1
-16	2098K60P004	. CAPACITOR, FIXED ELECTROLYTIC, 50 UF, 50 WVDC .		3
-17	6143K12P079	. RESISTOR, FIXED, COMPOSITION, 1.5 K ¤ 5%, . . . 1/2 W		1
-18	6705K90P010	. DIODE, SILICON		14
-19	5839K45P001	. RESISTOR, FIXED, COMPOSITION, 250 OHMS ¤ 20%, . 0.2 W		1
-20	6143K12P087	. RESISTOR, FIXED, COMPOSITION, 2.4 K ¤ 5%, . . . 1/2 W		1
-21	6146K15P206	. RESISTOR, FIXED, WIRE WOUND, 7.9 K ¤ 1%, 2.5 W		1
-22	2092K90P052	. CAPACITOR, FIXED CERAMIC, 0.47 UF PLUS 80% . . MINUS 20%, 50 WVDC		4
-23	6143K25P038	. RESISTOR, FIXED, COMPOSITION, 3.3 K ¤ 5%, 1/4 W		1
-24	8311K46P002	. TERMINAL STUD		24
-25	6146K15P204	. RESISTOR, FIXED, WIRE WOUND, 1.75 K ¤ 1%, 2.5 W		1
-26	2098K42P004	. CAPACITOR, FIXED, ELECTROLYTIC, 60 UF, 150 WVDC		1
-27	6707K60P001	. DIODE, BREAKDOWN		1
-28	2098K60P002	. CAPACITOR, FIXED, ELECTROLYTIC, 20 UF, 50 WVDC		1
-29	6146K15P052	. RESISTOR, FIXED, WIRE WOUND, 500 OHMS ¤ 1%, . . 2.5 W		1
-30	2098K60P010	. CAPACITOR, FIXED, ELECTROLYTIC, 3 UF, 50 WVDC .		1
-31	2098K60P009	. CAPACITOR, FIXED, ELECTROLYTIC, 5 UF, 50 WVDC .		1
-32	2098K42P002	CAPACITOR, FIXED, ELECTROLYTIC, 250 UF, 50 WVDC		2
-33	6143K26P009	. RESISTOR, FIXED, COMPOSITION, 5.1 K ¤ 5%, 1/4 W		2
-34	6143K25P023	. RESISTOR, FIXED, COMPOSITION, 62 OHM ¤ 5%, . . 1/4 W		2
-35	8600K44P003	. TRANSFORMER, ISOLATION		3
-36	6143K25P043	. RESISTOR, FIXED, COMPOSITION, 15 K ¤ 5%, 1/4 W		4
-37	6705K90P010	. DIODE, BREAKDOWN		2
-38	6854K90P024	. TRANSISTOR		1
-39	6143K25P042	. RESISTOR, FIXED, COMPOSITION, 15 MEG ¤ 10%, . . 1/4 W		2
-40	6144K16P029	. RESISTOR, FIXED, WIRE WOUND, 500 OHMS ¤ 5%, 3 W		1
-41	6707K10P064	. DIODE, BREAKDOWN		1
-42	2092K90P077	. CAPACITOR, FIXED, CERAMIC, 0.05 UF PLUS 80% . . MINUS 20%, 50 WVDC		1
-43	6845K90P013	. TRANSISTOR		2
-44	6143K25P044	. RESISTOR, FIXED, COMPOSITION, 8.2 K ¤ 5%, 1/4 W		2
-45	2108K90P182	. CAPACITOR, FIXED, PLASTIC, DIELECTRIC . . . . . 0.082 UF ¤ 10%, 200 WVDC		1
-46	5839K45P002	. RESISTOR, VARIABLE, COMPOSITION, 1 K ¤ 20%, . . 0.2 W		1
-47	6859K90P003	. TRANSISTOR		1
-48	6143K12P073	. RESISTOR, FIXED, COMPOSITION, 1 K ¤ 5%, ... 1/2 W		1
-49	2108K60P001	. CAPACITOR, FIXED, PLASTIC, DIELECTRIC, ... 0.01 UF ¤ 10%, 200 WVDC		1
-50	6143K25P041	. RESISTOR, FIXED, COMPOSITION, 82 K ¤ 10%, 1/4 W		3
-51	6143K25P026	. RESISTOR, FIXED, COMPOSITION, 1 OHM ¤ 5%, 1/4 W		1
-52	6143K25P025	. RESISTOR, FIXED, COMPOSITION, 6.2 K ¤ 5%, 1/4 W		4
-53	6705K90P003	. DIODE, SILICON		2
-54	6854K90P021	. TRANSISTOR		1
-55	2090K14P002	. CAPACITOR, FIXED, MICA DIELECTRIC, 2 UUF ¤ 5%, 500 WVDC		1
-56	6705K60P001	. DIODE, SILICON		1
-57	2098K91P003	. CAPACITOR, FIXED, ELECTROLYTIC, 750 UF PLUS . . 100% MUNUS 10%, 6 WVDC		1
-58	6702K60P001	. DIODE, GERMANIUM		3
-59	6143K25P035	. RESISTOR, FIXED, COMPOSITION, 100 OHM ¤ 10%, . 1/4 W, SEE NOTE 1		1
	6143K25P023	. RESISTOR, FIXED, COMPOSITION, 62 OHMS ¤ 5%, . . 1/4 W, SEE NOTE 1		1
	6143K25P040	. RESISTOR, FIXED, COMPOSITION, 130 OHMS ¤ 5%, . 1/4 W, SEE NOTE 1		1
-60	6143K25P037	. RESISTOR, FIXED, COMPOSITION, 27 OHMS ¤ 5%, . . SEE NOTE 1		1
	6143K25P026	. RESISTOR, FIXED, COMPOSITION, 10 OHMS ¤ 5%, . . 1/4 W, SEE NOTE 1		1
	6143K25P039	. RESISTOR, FIXED, COMPOSITION, 75 OHMS ¤ 5%, . . 1/4 W, SEE NOTE 1		1
-61	6143K25P008	. RESISTOR, FIXED, COMPOSITION, 200 OHMS ¤ 5%, . 1/4 W		1
-62	2108K90P122	. CAPACITOR, FIXED, PLASTIC, DIELECTRIC . . . . . 0.022 UF ¤ 10%, 200 WVDC		1
-63	6143K25P028	. RESISTOR, FIXED, COMPOSITION, 10 MEG ¤ 5%, . . . 1/4 W		1
-64	6854K90P023	. TRANSISTOR		1
-65	1600K45P001	. PRINTED CIRCUIT BOARD		1

Note 1: Value is determined at final factory test. Replace with resistor of

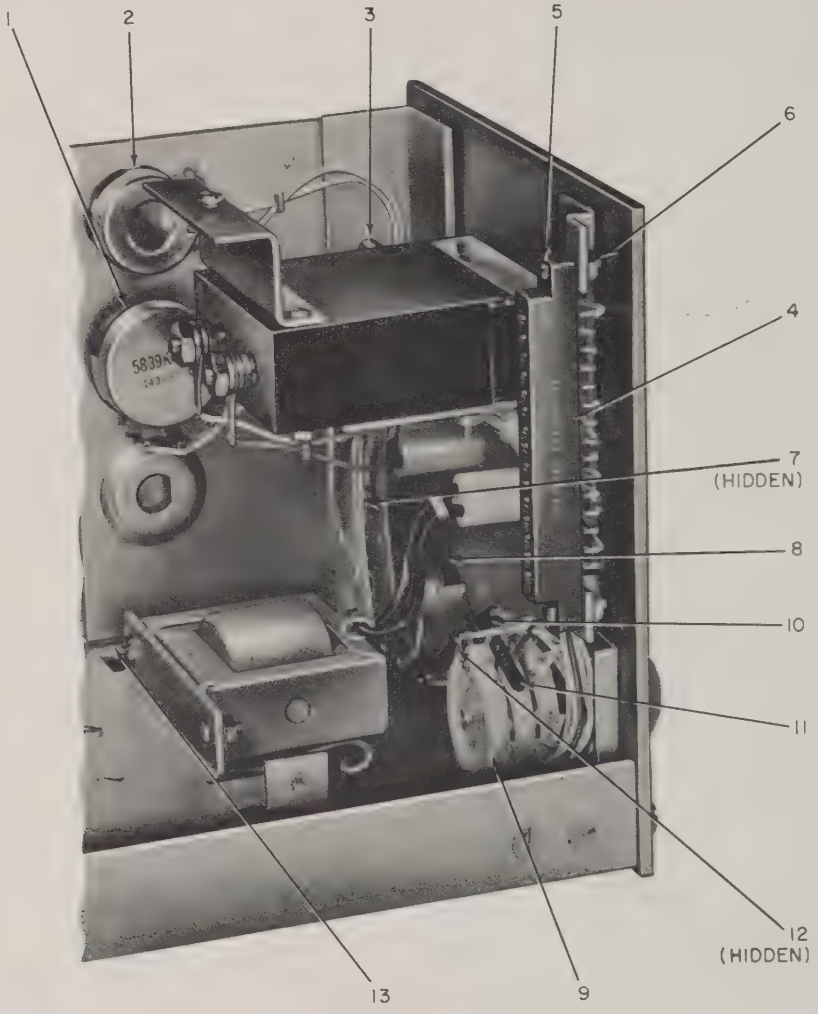


Fig. 23. Panel assembly

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
23 -	5558K60G700	PANEL ASSEMBLY, SEE 22 FIGURE 19 FOR NHA		REF
-1	5839K43P001	. RESISTOR, VARIABLE, WIRE WOUND, ... 500 OHMS ◻ 10%, 2 W		1
-2	5839K42P011	. RESISTOR, VARIABLE, COMPOSITION, ... 500 OHMS ◻ 20%, 1/2 W		1
-3	4643K40P020	. JACK, TEST, RED		1
-4	6029K60P001	. CONNECTOR, RECEPTACLE, ELECTRICAL . . . . . ATTACHING PARTS		1
-5	*N75P9008E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 1/4 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
-6	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL		2
		---*---		
-7	4643K40P021	. JACK, TEST, BLACK		1

*Minimum order quantity: 100 pieces

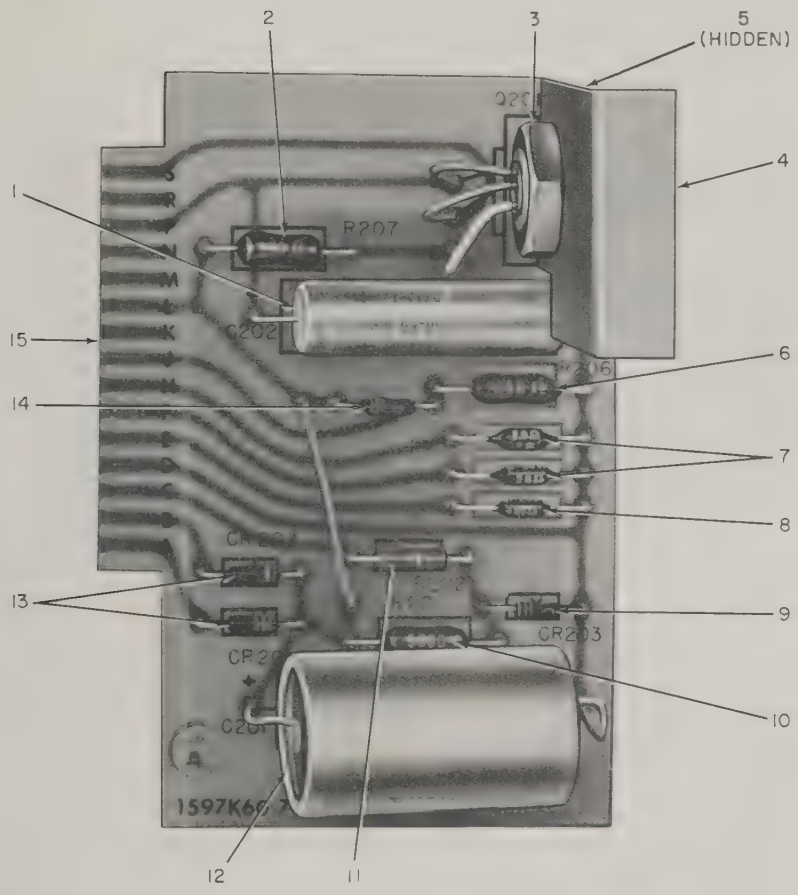


Fig. 24. Printed circuit board assembly

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
23 -8	5839K40P005	. POTENTIOMETER, COMPOSITION, 500 OHMS ¤ 10%, . . 1/2 W		1
	8167K60G700	. SWITCH ASSEMBLY		1
-9	8158K40P004	. . SWITCH, SELECTOR, 3 POSITION		1
-10	6143K12P109	. . RESISTOR, FIXED, COMPOSITION, 10 K ¤ 5%, . . 1/2 W		1
-11	6147K10P382	. . RESISTOR, FIXED, FILM, CARBON, 6.98 K ¤ 1%, . 1/8 W		1
-12	6143K12P120	. . RESISTOR, FIXED, COMPOSITION, 20 K ¤ 5%, . . 1/2 W		2
-13	5559K41P001	. PANEL		1
24 -	1597K60G700	PRINTED CIRCUIT BOARD ASSEMBLY, ... SEE 24 FIGURE 19 FOR NHA		REF
-1	2098K92P151	. CAPACITOR, FIXED, ELECTROLYTIC, 50 UF, 50 WVDC		1
-2	6144K16P018	. RESISTOR, FIXED, WIRE WOUND, 100 OHMS ¤ 5%, 3 W		1
-3	6847K90P005	. TRANSISTOR		1
-4	1695K52P001	. BRACKET		1

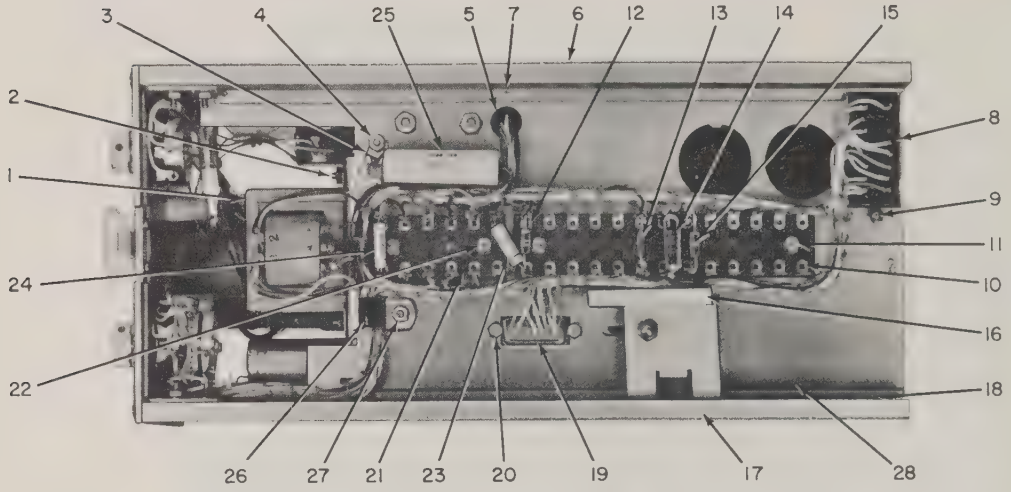


Fig. 25. Chassis plate assembly

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
		ATTACHING PARTS		
24 -5	*N75P13005E	. SCREW, MACHINE, PAN HD, NO. 6-32NC2A BY . . . . 5/16 IN. LG, BRASS, NI PL		2
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . 0.021 IN. THICK, PH BRZ, NI PL		2
	*N250P13E	. NUT, PLAIN, HEXAGON, NO. 6-32NC2B, BRASS, NI PL		2
		---*---		
-6	6144K16P045	. RESISTOR, FIXED, WIRE WOUND, 2.25 K ¤ 5%, 3 W .		1
-7	6148K60P050	. RESISTOR, FIXED, WIRE WOUND, 20 OHMS ¤ 1%, . . 1/4 W		2
-8	6148K60P049	. RESISTOR, FIXED, WIRE WOUND, 150 OHMS ¤ 1%, . . 1/4 W		1
-9	6707K10P061	. SEMICONDUCTOR DEVICE, DIODE		2
-10	6144K16P052	. RESISTOR, FIXED, WIRE WOUND, 5 K ¤ 5%, 3 W . .		1
-11	6143K12P076	. RESISTOR, FIXED, WIRE WOUND, 1.2 5 ¤ 5%, 1/2 W		1
-12	2098K94P046	. CAPACITOR, FIXED, ELECTROLYTIC, 50 UF, ... 150 WVDC		1
-13	6705K90P010	. SEMICONDUCTOR DEVICE, DIODE		2
-14	6707K10P025	. SEMICONDUCTOR DEVICE, DIODE		1
-15	1600K44P001	. PRINTED CIRCUIT BOARD		1
25 -	5719K60G700	CHASSIS PLATE ASSEMBLY, ... SEE 28 FIGURE 19 FOR NHA		REF
-1	8608K40P001	. TRANSFORMER, POWER		1
		ATTACHING PARTS		
-2	*N75P13005E	. SCREW, MACHINE, PAN HD, NO. 6-32NC2A BY . . . . 5/16 IN LG, BRASS, NI PL		2
	*N414P13E	. WASHER, LOCK, INT TOOTH, NO. 6, 0.295 OD BY . . 0.021 IN. THICK, PH BRZ, NI PL		2
	*N250P13E	. NUT, PLAIN, HEXAGON, NO. 6-32NC2B, BRASS, NI PL		2
		---*---		
-3	8311K42P008	. TERMINAL, LUG		1
		ATTACHING PARTS		
-4	*N75P13005E	. SCREW, MACHINE, PAN HD, NO. 6-32NC2A BY . . . . 5/16 IN. LG, BRASS, NI PL		1
	*N250P13E	. NUT, PLAIN, HEXAGON, NO. 6-32NC2B, BRASS, NI PL		1
		---*---		

*Minimum order quantity: 100 pieces

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
25 -5	4029K10P008	. GROMMET, RUBBER		1
-6	5974K40P001	. RAIL		1
		ATTACHING PARTS		
-7	*N75P9003E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 3/16 IN. LG, BRASS, NI PL		2
		---*---		
-8	2603K40P103	. CONNECTOR, RECEPTACLE, ELECTRICAL		1
		ATTACHING PARTS		
-9	N75P9006E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 3/8 IN LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL		1
	*N25P9E	---*---		
-10	1594K62P005	. TERMINAL BOARD		1
		ATTACHING PARTS		
-11	*N75P9005E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 5/16 IN. LG, BRASS, NI PL		2
	4594K40P001	. INSULATOR		1
	*N401P5E	. WASHER, FLAT, NO. 4, 0.125 ID BY 0.250 OD BY . 0.032 IN. THICK, BRASS, NI PL		2
	*8900K27P004	. WASHER, FLAT		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL		2
		---*---		
-12	6143K12P145	. RESISTOR, FIXED, COMPOSITION, 100 K ¤ 5%, 1/2 W		1
-13	6148K60P058	. RESISTOR, FIXED, WIRE WOUND, 1 OHM ¤ 0.1%, . . 1/4 W		1
-14	6144K17P030	. RESISTOR, FIXED, WIRE WOUND, 600 OHMS ¤ 5%, 5 W		1
-15	6143K12P037	. RESISTOR, FIXED, COMPOSITION, 100 OHMS ¤ 5%, . 1/2 W		1
-16	8089K62P002	. SUPPORT		1
		ATTACHING PARTS		
	*N125P904C11	. SCREW, SELF-TAPPING, FLAT HD, NO. 4-24 BY . . . 1/4 IN. LG, STL, CAD PL		2
		---*---		
-17	5974K40P002	. RAIL		1
		ATTACHING PARTS		
-18	*N47P9003E	. SCREW, MACHINE, FLAT HD, NO. 4-40NC2A BY . . . 3/16 IN. LG, BRASS, NI PL		2
		---*---		
-19	5730K90P004	. CONNECTOR, RECEPTACLE, ELECTRICAL		1
		ATTACHING PARTS		
-20	*N75P9006E	. SCREW, MACHINE, PAN HD, NO. 4-40NC2A BY . . . . 3/8 IN. LG, BRASS, NI PL		2
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL		2
		---*---		
-21	1594K62P004	. TERMINAL BOARD		1
		ATTACHING PARTS		
-22	6566K62P001	. SCREW		2
	4594K40P005	. INSULATOR		1
	*N401P5E	. WASHER, FLAT, NO. 4, 0.125 ID BY 0.250 OD BY . 0.032 IN. THICK, BRASS, NI PL		2
	*8900K27P004	. WASHER, FLAT		2
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL		2
		---*---		
-23	2108K13P061	. CAPACITOR FIXED, MYLAR 0.047 UF ¤ 10%		1
-24	2108K13P059	. CAPACITOR, FIXED, MYLAR 0.022 UF ¤ 10%		1
-25	2108K13P067	. CAPACITOR, 0.47 UF ¤ 10%, 100 WVDC		1
-26	2343K11P005	. CABLE, CLAMP		1
		ATTACHING PARTS		
-27	*N47P9005E	. SCREW, MACHINE, FLAT HD, NO. 4-40NC2A BY . . . 5/16 IN. LG, BRASS, NI PL		1
	*8915K60P001	. WASHER		1
	*N414P11E	. WASHER, LOCK, INT TOOTH, NO. 4, 0.270 OD BY . . 0.019 IN. THICK, PH BRZ, NI PL		1
	*N250P9E	. NUT, PLAIN, HEXAGON, NO. 4-40NC2B, BRASS, NI PL		1
		---*---		
-28	5700K65G700	. PLATE ASSEMBLY		1
	5678K44P001	. . PLATE		1
	5438K60P005	. . NUT, CLINCH, NO. 4-40		1

*Minimum order quantity: 100 pieces

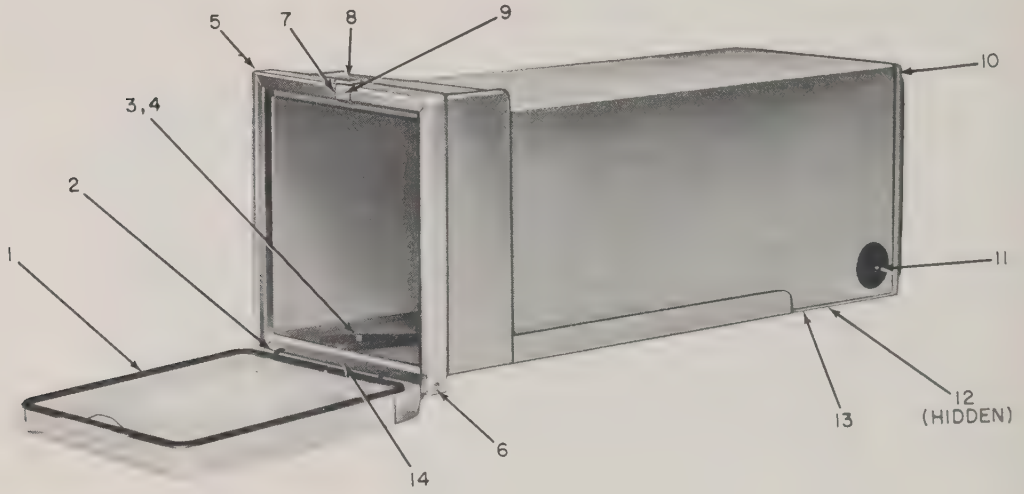


Fig. 26. Case assembly

FIG. AND INDEX NO.	PART NO.	DESCRIPTION 1 2 3 4 5 6 7	USAGE CODE	UNITS PER ASSY
26 -	2177K60G700	CASE ASSEMBLY, SEE 4 FIGURE 18 FOR NHA		REF
-1	3216K40G701	. DOOR ASSEMBLY		1
	2390K40P001	. . CLIP		2
	2300K40P002	. . DOOR, CAST		1
	3829K42P001	. . GASKET		1
	4889K41P001	. . LATCH		1
	5691K43P007	. . PLATE, INFORMATION		1
-2	6311K12P010	. O-RING		2
-3	4892K40G700	. LATCH ATTACHING PARTS		1
-4	N326P12008E	. RIVET, OVAL HD, SEMI TUBE ---*---		2
-5	3632K40P002	. FLANGE ATTACHING PARTS		1
-6	*N40P9010E	. SCREW, MACHINE, FIL HD, NO. 4-40NC2A BY 5/8 IN. LG, BRASS, NI PL ---*---		2
-7	5693K41P001	. PLATE, STRIKER		1
-8	1338K41P001	. BAR, RELEASE ATTACHING PARTS		1
-9	*N58P6003	. SCREW, MACHINE, FLAT HD, NO. 3-56NF2A BY 3/16 IN. LG, SST, PASSIVATED ---*---		1
-10	2827K40G701	. COVER		1
	*N44P21008E	. . SCREW, MACHINE, FIL HD, 1/4-20NC2A BY 3/8 IN. LG, STL, NI PL		2
	*5423K60P001	. . NUT, TEE, 1/4-20		2
	7923K40P001	. . SPRING		2
	3829K42P001	. . GASKET		1
	2839K40P002	. . COVER		1
-11	5727K60P003	. BUTTON PLUG		2
-12	5727K60P006	. BUTTON PLUG		2
-13	2169K40G700	. CASE		1
-14	4200K40G701	. HINGE ASSEMBLY		1
	4190K40P002	. . HINGE		1
	5670K40P001	. . PIVOT		2
	7923K42P001	. . SPRING		1

*Minimum order quantity: 100 pieces

NUMERICAL PARTS LIST

PART NO.	FIG. AND INDEX NO.	QTY PER INSTRUMENT
N125P904C11	25-16	2
N195P1506	19-19	2
N195P903	19-9	4
N207P13E	20-2	4
	20-7	
N250P13E	19-10	12
	19-23	
	24-5	
	25-2	
	25-4	
N250P7E	21-6	2
N250P9E	19-17	20
	19-21	
	21-8	
	21-9	
	21-10	
	23-6	
	25-9	
	25-11	
	25-20	
	25-22	
	25-27	
N326P12008E	26-4	2
N330P1205E	21-8	2
N364P902	19-3	2
	19-5	
N40P9010E	26-6	2
N40P9018E	19-17	2
N401P5E	25-11	6
	25-22	
N414P11E	19-15	21
	19-17	
	19-21	
	21-8	
	21-9	
	21-10	
	23-5	
	25-9	
	25-11	
	25-20	
	25-27	
N414P13E	18-6	24
	18-8	
	19-2	
	19-10	
	19-23	
	20-2	
	20-7	
	24-5	
	25-2	
N414P9E	21-6	2
N43P13008E	20-7	1
N44P21008E	26-10	2
N47P13005E	21-5	2
N47P13009E	19-23	4
N47P9003E	25-18	2
N47P9005E	21-8	5
	21-10	
	25-27	
N58P6003	26-9	1
NN632P13003E	21-4	2
N634P902	19-3	4
	19-5	
	19-6	
	19-12	
N75P13003E	18-8	6
	21-2	
N75P13004E	19-2	1
N75P13005E	24-5	5
	25-2	
	25-4	
N75P13006E	18-6	4
N75P7004E	21-6	2
N75P9003E	19-25	3
	25-7	
N75P9004E	21-9	2
N75P9005E	19-15	4
	25-11	
N75P9006E	25-9	4
	25-20	
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N75P9020E	19-21	2
1096K41G700	19-20	1
1338K41P001	26-8	1
1338K42P001	19-16	1
1594K62P004	25-21	1
1594K62P005	25-10	1
1594K66G700	20-17	1
1596K62G700	20-6	1
1597K60G700	19-24	1
1597K63G700	21-3	1
1600K44P001	24-15	1
1600K45P001	22-65	1
1695K42P001	20-6	1
1695K52P001	24-4	1
1696K68P001	21-8	1
1696K69P001	19-21	1
1696K70P001	21-10	1
1714K63G700	21-8	1
1714K64G700	19-21	1
1714K65G700	20-6	1
185112CYCY1AAB	19-17	1
1952K60G700	18-5	1
2090K14P002	22-55	1
2092K90P026	22-8	1
2092K90P052	22-22	4
2092K90P077	22-42	1
2098K42P002	22-32	2
2098K42P004	22-26	1
2098K60P002	22-28	1
2098K60P003	22-5	3
2098K60P004	22-16	3
2098K60P009	22-31	1
2098K60P010	22-30	1
2098K91P003	22-57	1
2098K92P151	24-1	1
2098K94P046	24-12	1
2101K40P002	20-9	1
2101K41P001	20-2	1
2107K60P001	20-10	1
2108K13P059	25-24	1
2108K13P061	25-23	1
2108K13P067	20-8	1
2108K60P001	22-49	1
2108K90P122	22-62	1
2108K90P182	22-45	1
2166K40P001	21-12	1
2169K40G700	26-13	1
2177K60G700	18-4	1
2289K40G700	18-3	1
2300K40P002	26-1	1
2343K11P005	25-26	1
2390K40P001	26-1	2
2407K40P001	19-4	4
2603K40P103	25-8	1
2691K60G700	18-	1
2817K44P001	21-2	1
2827K40G701	26-10	1
2827K46G700	21-1	1
2839K40P002	26-10	1
3103K40G700	19-3	1
3103K40G701	19-6	1
3103K40G703	19-5	1
3216K40G701	26-1	1
3632K40P002	26-5	1
3744K11P035	18-6	1

PART NO.	FIG. AND INDEX NO.	QTY PER INSTRUMENT
3829K42P001	26-1	2
	26-10	
3919K40G700	19-10	1
4029K10P008	25-5	1
4039K40P001	19-2	1
4042K40G700	19-1	1
4068K60P001	22-11	1
4113K40P001	19-15	1
4190K40P002	26-14	1
4200K40G701	26-14	1
4220K60P001	19-13	1
4220K60P002	19-14	1
4223K62G700	19-13	1
4223K62G701	19-14	1
4226K40P002	18-6	1
4579K41P001	18-9	1
4579K43P001	21-2	1
4579K43P002	19-2	1
4594K40P001	25-11	1
4594K40P005	25-22	1
4594K60P001	21-6	1
4643K40P020	23-3	1
4643K40P021	23-7	1
4798K62P001	19-12	2
4889K41P001	26-1	1
4892K40G700	26-3	1
5423K60P001	26-10	2
5438K60P004	19-21	1
5438K60P005	25-28	1
5535K40P001	22-2	8
5558K60G700	19-22	1
5559K41P001	23-13	1
5670K40P001	26-14	2
5678K44P001	25-28	1
5681K40P001	18-7	1
5681K41P001	19-27	1
5689K60P001	18-1	1
5689K60P002	19-26	1
5691K43P002	19-18	1
5691K43P005	19-8	1
5691K43P007	26-1	1
5691K43P010	19-7	1
5693K41P001	26-7	1
5700K65G700	25-28	1
5719K60G700	19-28	1
5727K60P002	19-11	2
5727K60P003	26-11	2
5727K60P006	26-12	2
5730K90P003	21-9	1
5730K90P004	25-19	1
5809K66P001	20-7	2
5839K40P001	20-5	1
5839K40P004	20-1	1
5839K40P005	23-8	1
5839K40P006	20-4	1
5839K42P011	23-2	1
5839K43P001	23-1	1
5839K45P001	22-19	1
5839K45P002	22-46	1
5974K40P001	25-6	1
5974K40P002	25-17	1
6029K60P001	23-4	1
6143K12P033	20-14	1
6143K12P037	25-15	1
6143K12P063	20-15	1
6143K12P073	22-48	1
6143K12P076	24-11	1
6143K12P079	22-17	1
6143K12P087	22-20	1
6143K12P091	20-13	1
6143K12P109	20-11	2
	23-10	
6143K12P112	20-12	1
6143K12P120	20-16	2
	23-12	
6143K12P145	25-12	1
6143K25P008	22-61	1
6143K25P023	22-59	2

PART NO.	FIG. AND INDEX NO.	QTY PER INSTRUMENT
6143K25P023 (CONT)	22-34	
6143K25P025	22-52	4
6143K25P026	22-51	2
	22-60	
6143K25P028	22-63	1
6143K25P029	22-9	1
6143K25P030	22-7	1
6143K25P031	22-4	1
6143K25P032	22-14	1
6143K25P033	22-3	1
6143K25P035	22-59	1
6143K25P037	22-60	1
6143K25P038	22-23	1
6143K25P039	22-60	1
6143K25P040	22-59	1
6143K25P041	22-50	3
6143K25P042	22-39	2
6143K25P043	22-36	4
6143K25P044	22-44	2
6143K25P045	22-15	1
6143K25P046	22-6	2
6143K26P009	22-33	2
6144K16P018	24-2	1
6144K16P029	22-40	1
6144K16P045	24-6	1
6144K16P052	24-10	1
6144K17P030	25-14	1
6146K15P052	22-29	1
6146K15P204	22-25	1
6146K15P206	22-21	1
6147K10P382	23-11	1
6148K60P049	24-8	1
6148K60P050	24-7	2
6148K60P058	25-13	2
6311K12P010	26-2	2
6566K62P001	25-22	2
6702K60P001	22-58	3
6705K60P001	22-56	1
6705K90P003	22-53	2
6705K90P010	22-18	18
	22-37	
	24-13	
6707K10P025	24-14	1
6707K10P061	24-9	2
6707K10P064	22-41	1
6707K60P001	22-27	1
6845K90P013	22-43	2
6845K90P019	22-12	1
6847K90P005	24-3	1
6854K90P009	22-13	1
6854K90P010	22-10	1
6854K90P021	22-54	1
6854K90P023	22-1	2
	22-64	
6854K90P024	22-38	1
6856K90P011	21-7	1
6859K90P003	22-47	1
7923K40P001	26-10	2
7923K42P001	26-14	1
8065K60P002	21-8	1
8072K60P001	20-6	2
8089K62P002	25-16	1
8096K45G700	18-2	1
8155K60P001	20-3	1
8158K40P004	23-9	1
8167K60G700	23-8	1
8311K17P003	21-11	1
8311K27P002	19-13	4
	19-14	
8311K42P008	25-3	1
8311K46P002	22-24	24
8600K44P003	22-35	3
8600K61P001	21-5	1
8608K40P001	25-1	1
8900K27P004	25-11	4
	25-22	
8900K70P007	21-6	2
8915K60P001	25-27	1

REFERENCE DESIGNATION LIST

REFERENCE DESIGNATION	FIG. AND INDEX NO.	PART NO.	REFERENCE DESIGNATION	FIG. AND INDEX NO.	PART NO.
C1	20-10	2107K60P001	Q24	22-10	6854K90P010
C2	20-2	2101K41P001	Q25	22-13	6854K90P009
C3	20-9	2101K40P002	Q26	22-38	6854K90P024
C21	22-62	2108K90P122	Q27	22-43	6845K90P013
C22	22-5	2098K60P003	Q28	22-47	6859K90P003
C23	22-16	2098K60P004	Q29	22-64	6854K90P023
C24	22-8	2092K90P026	Q30	21-7	6856K90P011
C25	22-16	2098K60P004	Q201	24-3	6847K90P005
C26	22-57	2098K91P003	R1	20-5	5839K40P001
C27	22-5	2098K60P003	R2	20-1	5839K40P004
C28	22-22	2092K90P052	R3	20-4	5839K40P006
C29	22-42	2092K90P077	R4	20-11	6143K12P109
C30	22-45	2108K90P182	R5	20-16	6143K12P120
C31	22-16	2098K60P004	R6	20-14	6143K12P033
C32	22-22	2092K90P052	R7	20-15	6143K12P063
C33	22-30	2098K60P010	R8	20-13	6143K12P091
C34	22-31	2098K60P009	R10	20-12	6143K12P112
C35	22-5	2098K60P003	R21	22-50	6143K25P041
C36	22-55	2090K14P002	R22	22-50	6143K25P041
C37	22-28	2098K60P002	R23	22-23	6143K25P038
C38	22-32	2098K42P002	R24	22-39	6143K25P042
C39	22-32	2098K42P002	R25	22-51	6143K25P026
C40	22-26	2098K42P004	R26	22-60	6143K25P037
C41	22-22	2092K90P052	R26	22-60	6143K25P026
C42	22-22	2092K90P052	R26	22-60	6143K25P039
C43	22-49	2018K60P001	R27	22-59	6143K25P035
C101	25-24	2108K13P059	R27	22-59	6143K25P023
C103	25-23	2108K13P061	R27	22-59	6143K25P040
C104	25-25	2108K13P067	R28	22-61	6143K25P008
C163	20-8	2108K13P067	R29	22-44	6143K25P044
C201	24-12	2098K94P046	R30	22-63	6143K25P028
C202	24-1	2098K92P151	R31	22-9	6143K25P029
CR21	22-53	6705K90P003	R32	22-7	6143K25P030
CR22	22-53	6705K90P003	R33	22-4	6143K25P031
CR23	22-56	6705K60P001	R34	22-6	6143K25P046
CR24	22-58	6702K60P001	R35	22-15	6143K25P045
CR25	22-58	6702K60P001	R36	22-14	6143K25P032
CR26	22-58	6702K60P001	R37	22-52	6143K25P025
CR27	22-18	6705K90P010	R38	22-52	6143K25P025
CR28	22-18	6705K90P010	R39	22-52	6143K25P025
CR29	22-18	6705K90P010	R40	22-52	6143K25P025
CR30	22-18	6705K90P010	R43	22-3	6143K25P003
CR31	22-18	6705K90P010	R44	22-40	6144K16P029
CR32	22-18	6705K90P010	R45	22-6	6143K25P046
CR33	22-41	6707K10P064	R46	22-39	6143K25P042
CR34	22-18	6705K90P010	R47	22-19	5839K45P001
CR35	22-37	6705K90P010	R48	22-33	6143K26P009
CR36	22-37	6705K90P010	R49	22-36	6143K25P043
CR37	22-18	6705K90P010	R50	22-33	6143K26P009
CR38	22-27	6707K60P001	R51	22-36	6143K25P043
CR39	22-18	6705K90P010	R52	22-36	6143K25P043
CR40	22-18	6705K90P010	R53	22-44	6143K25P044
CR41	22-18	6705K90P010	R54	22-46	5839K45P002
CR42	22-18	6705K90P010	R55	22-48	6143K12P073
CR43	22-18	6705K90P010	R56	22-17	6143K12P079
CR44	22-18	6705K90P010	R57	22-20	6143K12P087
CR201	24-13	6705K90P010	R58	22-36	6143K25P043
CR202	24-13	6705K90P010	R59	22-34	6143K25P025
CR203	24-9	6707K10P061	R60	22-25	6146K15P204
CR204	24-14	6707K10P025	R61	22-29	6146K15P052
DS1	19-14	4220K60P002	R62	22-21	6146K15P206
DS2	19-13	4220K60P001	R63	22-50	6143K25P041
F1	18-6	3744K11P035	R103	25-12	6143K12P145
J1	25-8	2603K40P103	R105	23-12	6143K12P120
J2	25-19	5730K90P004	R106	23-10	6143K12P109
J3	23-4	6029K60P001	R109	23-11	6147K10P382
J4	23-3	4643K40P020	R110	25-15	6143K12P037
J5	23-7	4643K40P021	R111	23-8	5839K40P005
M101	19-17	185112CYCY1AAB	R112	23-1	5839K43P001
P2	21-9	5730K90P003	R113	23-2	5839K42P011
Q21	22-54	6854K90P021	R115	25-14	6144K17P030
Q22	22-1	6854K90P023	R116	25-13	6148K60P058
Q23	22-12	6845K90P019	R117	23-12	6143K12P120

REFERENCE DESIGNATION	FIG. AND INDEX NO.	PART NO.	REFERENCE DESIGNATION	FIG. AND INDEX NO.	PART NO.
R201	24-10	6144K16P052	S1	23-9	8158K40P004
R202	24-11	6143K12P076	S2	20-3	8155K60P001
R203	24-8	6148K60P049	T21	22-35	8600K44P003
R204	24-7	6148K60P050	T22	22-35	8600K44P003
R205	24-7	6148K60P050	T23	22-35	8600K44P003
R206	24-6	6144K16P045	T24	21-5	8600K61P001
R207	24-2	6144K16P018	T101	25-1	8608K40P001

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